SCIENCE ABSTRACTS.

Section A.—PHYSICS.

AUGUST 1917.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

AUGUST 1917.

GENERAL PHYSICS.

708. *Some suggested Improvements in Wireless Time Signals.* **W. E. Cooke and F. B. Cooke.** (Roy. Astron. Soc., M.N. 77. pp. 469–478, March, 1917.)—The object of this paper is to indicate a method whereby two clocks or chronometers, separated by some 5000 miles or so, may be compared with an error not exceeding 1/100 sec., and with entire elimination of the personal equation.

Three, or perhaps four, stations are concerned. Calling the two astronomical stations A and B, a third station C (the transmitting or signalling station) contains apparatus transmitting a series of dots regularly spaced at intervals of nearly, but not quite, one second apart. This station should be preferably about midway between A and B, but if this is impracticable, take two stations C_1 and C_2 close to A and B respectively, and each acting alternately as a transmitting station. Assume a single station C. The exact time of the dots is immaterial. Observers A and B receive the series of dot signals and compare it with the beats of their respective clocks, this being accomplished by the well-known method of coincidences. All that remains to be done is to determine the exact seconds at which the C signals coincide with the beats of the A or B clocks.

The principal difficulty appears to be that a very short, sharp dot cannot be radiated and received over long distances, and that if the dot is of appreciable length, different observers take different parts of it to form their coincidences with their clock-beats. The personal element also arises from the fact that the sound of the radio signal generally differs greatly from the sound of the clock-beat. The authors eliminate the personal element entirely by the following device :—Included in the clock circuit is a relay. In its normal inoperative position its back contact closes the circuit for the incoming signals, the armature and back contact being placed in series with the aerial. There is thus produced, automatically, interference between the clock-beats and the radio signals, and the latter will diminish gradually and then cease periodically. The coincidence may be taken either as the last audible signal or a second later.

The authors give as their opinion that the arc transmitter with an oscillating audion as receiver is superior to a spark and crystal system for this class of work.

The main principle can be used for the comparison of local clocks or chronometers, in particular for comparing mean sidereal time. In this case the mean-time clock takes the place of the clock used in the previous experiment, and the sidereal clock that of the wireless signals, the latter being placed in series with a battery and high-pitch buzzer. With this arrangement coincidences can be obtained with the greatest ease and certainty, and the slightest want of beat (irregularity of seconds) can be immediately and unmistakably detected.

The armature of the relay takes the form of a weighted pendulum, so that the duration of the contact made by it can be adjusted to any desired figure.
H. H. H.

709. *Impact Tests of the Resilience of Steel.* **G. Charpy** and **A. Cornu-Thenard.** (Comptes Rendus, 164. pp. 473–477, March 19, 1917. Rev. de Mét. 14. pp. 84–122. March–April, 1917.)—The discordant results obtained in tests with impact machines have led the authors to investigate whether this is due to errors of experiment or to difficulties inherent in the design of the machines. The authors have been able to prepare a series of samples giving consistent results, and they conclude that (i) the effect of the height of fall of the hammer is negligible under ordinary conditions, (ii) apparatus of various dimensions or types will give concordant results if properly constructed and graduated, (iii) the effect of the groove is considerable, the resilience becoming smaller as the depth of the groove increases, other conditions being maintained constant, (iv) the resilience of a metal, although not bearing any definite relation to other mechanical constants, is a perfectly definite quantity. To give it a numerical value it is necessary to compare specimens of perfectly defined geometric form.
J. W. T. W.

710. *Torsional Hysteresis of Mild Steel.* **J. J. Guest** and **F. C. Lea.** (Roy. Soc., Proc. 93. pp. 313–332, June 1, 1917.)—Gives an account of work undertaken to establish whether or not mild-steel rods exhibit hysteresis under torsional stresses much below the elastic limit. The special form of torsional extensometer employed in the experiments is described and illustrated in the paper, and from the large number of typical results tabulated and exhibited graphically it appears that, for the mild steel used in these tests the torsion stress-strain curve for a rising or falling load does not obey Hooke's law, and that, for a given range of torsion well below that which produces a stress equal to what is generally considered the elastic limit of a mild steel, whether wholly positive, negative, or changing sign, a hysteresis loop is obtained, so that the elastic limit as at present defined would appear to be zero. An examination of the curves given in the paper shows that for any given value of the torque, the slope of the stress-strain curve, and thus the modulus of rigidity, depends upon the way the stress is changing, and at any given stress, including zero stress, is not a constant quantity, but depends upon the previous history of the material.
J. W. T. W.

711. *Systematic Variation in the Value of the Kinetic Energy in the Elastic Impact of Bodies.* **L. Hartmann.** (Comptes Rendus, 164. pp. 491–494, March 19, 1917.)—This note is in continuation of other papers under a similar title [Abs. 1254 (1916), 449 (1917)]. A great number of modern writers assume, after Huyghens and Leibnitz, that the kinetic energy is rigorously conserved in elastic impact of bodies, and that any diminution in its value is due to permanent deformation in the impinging bodies. This hypothesis is not exact. Take for example two steel cylinders of masses m and m',

initial velocities V and O; the effective velocities after separation being ψ and ψ', the diminution of kinetic energy is $mV^2—(m\psi^2 + m'\psi'^2)$. According to the theory above, the cause of this diminution is an internal change in the cylinders, and these, if they were perfectly elastic, ought to take velocities ϕ and ϕ', such that $mV^2 = m\phi^2 + m'\phi'^2$. The diminution of kinetic energy would be $m\phi^2—m\psi^2 + m'\phi'^2—m'\psi'^2$, the "hammer" cylinder accounting for the quantity $m'\phi'^2 — m\psi^2$, and the "anvil" cylinder for $m'\phi'^2 — m'\psi'^2$. These quantities should both be positive whatever may be the masses.

If, however, $N = 2m/(m + m')$, it has previously been shown that $m\phi^2—m\psi^2 = (N—n)(N + n—2)$, and $m'\phi'^2 — m'\psi'^2 = m/m'(N^2 — n^2)mV^2$, where n is always less than N. It follows that the part $m'\phi'^2—m'\psi'^2$ is always positive, but that $m\phi^2— m\psi^2$ may be positive, zero, or negative. We must therefore reject the conception that the diminution of kinetic energy after impact in this case is compensated by a permanent deformation produced in the cylinders. T. B.

712. *Accelerated Motion of Droplets through a Viscous Medium.* **W. A. Shewhart.** (Phys. Rev. 9. pp. 425–433, May, 1917.)—The experimental results of this paper indicate that if a small sphere, moving down through a viscous medium with a terminal velocity v under a constant force is suddenly caused to vibrate at right angles to the original line of motion the vertical velocity component v is increased.

Three possible explanations are given: (1) Cavitation at the edge of the sphere would give rise to the phenomenon observed. (2) If the particle suddenly stops, as it does at the end of the oscillation, and starts to return the pressure will be greater on the upper side and will increase the vertical fall. (3) If the spherical drop of liquid suffers a distortion when it enters the electric field, this would affect the velocity. [See Abs. 116 (1914).] E. H. B.

713. *Special Test on Temperature Effect of Gravitation.* **P. E. Shaw** and **C. Hayes.** (Phys. Soc., Proc. 29. pp. 163–169; Disc., 170, April, 1917.)—From a research by one of the authors [see Abs. 860 (1916)] it was concluded that the temperature coefficient of gravitation was of the order $(1·2 \pm 0·05) \times 10^{-5}$ per 1 deg. C. But the point had been raised as to whether when the large masses were heated they swung in a little owing to convection currents and consequent decreased pressures as given by Bernoulli's theorem. By specially mounted screw-gauges (as used in spherometers) it is found that the masses were a little farther apart when heated. Thus instead of showing the temperature effect to be spurious this special test raises the coefficient. Its new value is here given as

$$(1·3 \pm 0·05) \times 10^{-5} \text{ per 1 deg. C.}$$

C. V. Boys felt P. E. Shaw's method of measuring separately the attractions at different temperatures was inferior to the plan of cold balls in one position opposed by hot balls in the other, and *vice versa.* This would be a null method and would measure only the temperature coefficient if such existed. **P. E. Shaw** pointed out difficulties in carrying out the above suggestions. E. H. B.

714. *Gravitation and Thermodynamics.* **P. E. Shaw.** (Nature, 99. p. 165, April 26, 1917.)—As pointed out by O. J. Lodge, the case cited by the author, of a disc pivoted about its centre of mass and started in motion, does not lead to perpetual motion in the ordinary sense. But, in the author's opinion, there would be long-sustained, oscillatory motion.

G. W. Todd suggested that this peculiar effect would not arise if $\partial\theta/\partial r$ is positive. We should then have the remaining peculiar effect, viz., a condition of neutral equilibrium would (by a rotation) be converted into one of stable equilibrium. Would this proposal satisfy philosophers? [See Abs. 972 (1916) and 458 (1917).] E. H. B.

715. *The Importance of Gravity Observations on the Pacific.* **J. F. Hayford.** (Nat. Acad. Sci., Proc. 2. pp. 394–398, July, 1916.)—It is considered that geodesy will furnish help to geology by revealing the flattening of the earth and by indicating outstanding excesses or deficiencies in density beneath the earth's surface and thus revealing data as to the geological history of any region. More geodetic information is needed now at sea than on land. For good determinations of *g* have been made at 3000 widely scattered stations on the one-quarter of the earth's surface which is land; whereas no reliable observations have yet been made on the three-quarters of the surface which is sea. Mention is made of the computations made by F. R. Helmert, and also by W. Bowie, of the earth's polar flattening. The former made no correction for topography and isostatic compensation; the latter applied such corrections. The author considers that Bowie's result from 122 gravity observations in a small region are more reliable than Helmert's value from 700 carefully selected and widely scattered observations. Observations along the coasts stand in a class by themselves; those in low interior regions and those in mountains and those in oceanic islands, in other classes severally. Each class, as Helmert showed, is subject to peculiar systematic errors. Good observations at sea should serve to link together all the land observations and, further, they would be less subject to topographical error.

For determining the depth below the earth's surface at which masses of abnormal density lie, the sea observations would be more valuable than those on land. Other considerations are introduced by the author. The reasons why the Pacific Ocean is considered specially favourable are several and are specified. P. E. S.

716. *Measuring Gravity at Sea.* **L. J. Briggs.** (Nat. Acad. Sci., Proc. 2. pp. 399–407, July, 1916.)—Criticism is made of the Hecker barometer-hypsometer method for finding gravity at sea. Thus the boiling-point determinations must be carried out with the highest refinement to secure even moderate precision in *g*. There would result from such a process a probable error of at least 1 in 10,000 in determining *g*. In the new method described here the accuracy aimed at is 1 in 100,000. The apparatus used has a barometric column with vacuum above and atmosphere below as usual; but the atmosphere used is an artificial constant one of pure nitrogen sealed off from the atmosphere in a gas chamber. The barometric column of mercury is in a capillary tube, 0·6 mm. bore. The lower end of this tube is enclosed in the gas chamber to which it is sealed where it passes through the upper end. The upper part of the capillary is bent into a flexible zigzag and at the extreme top expands into a spherical bulb, 2 cm. diam., at the top of which is the vacuum. A fixed index point of iron is sealed on the top of the bulb. The flexible capillary is capable of slight movement up and down with respect to the gas chamber: a micrometer screw measures this movement.

Suppose the index point just touches the top mercury surface. If gravity increases, the flexible part would be shortened by the operator so as to bring the index again in contact with the mercury, and so on for any changes in g. The theory is very simple. Suppose gravity change from g to g_1 the barometric column having height h and the movement of the micrometer being Δh, then $g/g_1 = 1 - \Delta h/h$. The errors and disturbances (eight in number) are discussed. For harbour determinations, which are of course more favourable than those at sea, the mean probable error is 18 in 1,000,000. P. E. S.

717. *Deflection of the Vertical by Tidal Loading of the Earth's Surface.* **H. Lamb.** (Roy. Soc., Proc. 93. pp. 293–312, June 1, 1917.)—The earliest calculations on this subject in which the flexure of the earth's surface is taken into account, as well as the direct attraction of the water, were made by G. H. Darwin. He showed that in a particular case the tilting effect would conspire with the attraction, and would on certain assumptions be directly proportional to it. On inserting numerical values the apparent deflection due to tilting was found to exceed considerably that due to attraction. The whole subject has of late excited renewed attention, owing to its bearing on observations of lunar deflection of gravity, and in a recent paper by Terazawa [Abs. 997 (1916)] the matter is specially considered from the latter point of view. The present paper, after discussing a few typical problems, goes on to examine the effect of one or two considerations which have hitherto been disregarded in such calculations. It is true that the corrections involved are under some conditions negligible, but they are of theoretic interest, and it is found that at great distances from a load, and therefore in all cases of widely distributed load, they may attain considerable relative importance. In the first place, owing to the deformation of the earth's surface and the altered distribution of density, an additional horizontal component of force on the plumb-line is introduced; this tends to counteract the attraction of the water. A more important point is that the influence of gravity on the deformation has been ignored. In attempting to estimate the effect of gravity it has been found convenient, in order to avoid difficulties not altogether of a mathematical kind, to limit the investigation to the case of incompressibility. The author has also neglected, in the first instance, the disturbance in the field of gravity itself, due to the load and the deformation, so far as this affects the strains. When subsequently the alteration of the field is taken into account a curious point arises. For mathematical simplicity the earth has been treated as flat and infinitely extended. It appears that if this were the case the surface would be unstable, whatever the degree of rigidity, for disturbances exceeding a certain critical wave-length. This wave-length is, however, enormous, and reason is given for the view that inferences can still legitimately be drawn from the results as to the character of the effects actually produced.

In an appendix the author adds proofs of some of the formulæ involving Bessel's functions employed in the paper. H. H. Ho.

718. *The Propagation Velocity of Gravitation.* **P. Gerber.** (Ann. d. Physik, 52. 4. pp. 415–441, May 10, 1917.)—The author has previously shown that if it be assumed that the as yet unexplained perihelion motion of the planet Mercury depends upon a time consumption due to the spacial propagation of gravitation, then a value for the latter is obtained equal to the velocity of light, radiant heat, and electric waves. It has not yet been demonstrated that the amount of the perihelion motion of Mercury has any other origin. Should a value different from that of the velocity of light have been obtained, then the above assumption would have possessed no further importance, since it is in the agreement that credence has been afforded to the theory of a gravitational velocity which is finite. The present author claims, however, that the velocity value is an unexpected result on his theory, since all earlier experimental efforts have usually pointed to larger values. The paper now presented contains a detailed account of the author's gravitational investigations, and in it he concludes that the variations from the velocity of light, found by previous investigators, have their origin not in the nature of the calculations or choice of observations, but in the fundamental assumptions. In Section II of the paper the author states that three fundamental standpoints must be examined, which he then proceeds to discuss at some length. These are: (1) The general spacial ideas concerning gravitational processes between masses at rest and in motion. (2) The importance of gravitational potential. (3) The duration of the propagation in space in relation to the action on masses. The author opines that a velocity can only be ascribed to the potential, and not to the accelerating force. Section III contains a detailed review of previous work on the subject of gravitational velocity. Reference is first made to Oppenheim's exhaustive summary up to 1894–95. Laplace's investigations are first dealt with, being followed by those of Zöllner, Weber, Levy, Lehmann-Filhés, Hepperger, Drude, H. A. Lorentz, and others. The author comments that while physical theories have had for their object the establishment of a connection between different kinds of physical processes, such connection in the case of gravitation has not yet been found, so that as regards gravitational velocity some data are as yet undiscovered. In Section IV it is shown how from the fundamental positions raised in Section II, we are driven to an examination of the potential and to a modification of the Newtonian law for the determination of the influence of gravitational propagation upon mass motion. The author has obtained a value for the potential in an earlier investigation. The chief features of the calculation employed for Mercury are included in the paper. In Section V it is concluded that the spacial propagation of gravitation cannot be investigated without using a modification of the Newtonian law, although it is conceivable that cases exist in which the general law affords a simpler, and for these special cases an easier derived form. The general expressions given by the author for the potential and the accelerating force hold good for the gravitational motion, provided the velocities of the masses are small compared with the gravitational velocity. The author claims to have established that the medium for mass attraction is identical with that of light, radiant heat, electric waves, etc., and in consequence he has not had to introduce any controversial hypothesis. The present theory does not explain gravitation on purely mechanical grounds, although it establishes the connection between this phenomenon and other physical processes. H. H. Ho.

719. *The Special Vibrations of the Bohr-Debye Hydrogen Molecule, taking Account of the Nucleus Motion.* **A. Rubinowicz.** (Phys. Zeits. 18. pp. 187–195, May 1, 1917.)—From two different standpoints F. Krüger [see Abs. 14 (1917)] and P. S. Epstein have sought to explain the temperature relation of the specific heat of hydrogen by reference to the Bohr-Debye molecular model. Both authors thereby make the assumption that the thermal movement of the hydrogen molecule H_2, apart from its translation, takes the form of a regular precession, in which the model molecule moves as a rigid body symmetrically with respect to the line joining the two nuclei. In order to test the validity of this assumption [and it has not yet been clearly established that the H_2 model possesses the necessary stability for a precessional motion] the author here investigates the special vibrations of the hydrogen molecule from the standpoint of the nucleus motion. Since the mechanism of the Bohr model may possess special interest for the stability problem, and may also be of value for the dispersion theory, the calculation details are given in the paper. For the case where both nuclei are at rest, the special vibrations of van Leeuwen [see Abs. 754 (1916)] have been calculated. For determination of the special vibrations Lagrange's equations of the second order have been utilised, the potential and kinetic energies being developed from the disturbance coordinates. Section I of the paper contains the evaluation of the potential energy, while II deals with the kinetic energy of the hydrogen molecule. In III the equations for the free vibrations of the hydrogen molecule are established, while IV deals with the special vibrations and includes an exhaustive discussion of this problem, accompanied by illustrative diagrams. In Section V the special vibrations of complex Bohr molecules with movable nuclei are considered. The latter include molecules which consist of two nuclei with an electronic ring rotating in a plane perpendicular to the line joining the nuclei. If the two nuclei possess equal charges and masses as in the case of H_2, O_2, and N_2, then the molecules are symmetrical with respect to the electronic ring; otherwise they are unsymmetrical as in the case of HCl and CO. Section VI summarises the results with respect to the stability of the Bohr molecule and the dispersion formula consequent on the nucleus vibration. It is found that in the case of diatomic Bohr molecules with nucleus movement involved, no new unstable vibrations arise, although in the case of hydrogen one such vibration has been established. In spite of the small stability of the hydrogen molecule, however, a precessional vibration is always possible if the angle which the molecular axis makes with the direction of the external impulse is very small. For greater angles, such as are assumed in the theories of Krüger and Epstein, the author has been unable to draw exact conclusions with respect to precessional oscillations. An important result for the theory of dispersion is that with all the special vibrations in the symmetrical molecule brought into being by the oscillations of the nuclei, the electric moment remains zero. All the special oscillations are found not to be due in any way to external homogeneous electric waves, and as a consequence the Debye dispersion formula for hydrogen must be valid in the visible spectrum and also in the ultra-red, while the Sommerfeld dispersion formulæ for O_2 and N_2 are not essentially improved by taking account of the nucleus movement. It is otherwise with the relationships in the case of unsymmetrical diatomic molecules whose nuclei are very unequally charged. The special ultra-red oscillations, *i.e.* precessional vibrations, as also that calculated by Sommerfeld, are affected by light waves, and, in consequence, the dispersion is influenced. H. H. Ho.

720. *Hamilton's Principle in Einstein's Theory of Gravitation.* **H. A. Lorentz.** (K. Akad. Amsterdam, Proc. 19. 4. pp. 751–765, 1917.)—The author shows that Einstein's theory may be based upon a principle so similar to that of Hamilton that his name may quite properly be connected with it, and suggests that thereby the discussion of some parts of this theory may gain in simplicity and clearness. He considers in the first place a material point acted upon by a force with components K_1, K_2, K_3, in a field of force derivable from a Lagrangian function L, and to attain the four-dimensional form suitable to the expression of Einstein's results, he introduces a fourth component K_4, defined by the equation $K_4 = -(v_1K_1 + v_2K_2 + v_3K_3)$ which

may be written $\Sigma(a)v_a K_a = 0$. Then subject to this relation the motion is defined by the equation

$$\delta\int L\,dt + \int\Sigma(a)K_a\delta x_a\,dt = 0 \quad\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (1)$$

Then, as is shown by Einstein, the motion of the point of mass m in a gravitation field may be deduced from this principle by taking $L = -m\,ds/dt$, or in terms of Einstein's characteristic quantities g_{ab}, $L = -m\sqrt{\Sigma(ab)g_{ab}v_a v_b}$. Still following Einstein, consider a very large number of material points wholly free from each other, moving in a gravitation field so that at a definite instant their velocity components are continuous functions of the coordinates. By increasing the number indefinitely we pass to a continuously distributed matter without internal forces, and the laws of motion of such a system obviously follow from those of a single point. The fundamental principle is then obtained in the form: Let a variation of the motion of the system of material points be defined by the infinitely small quantities δx_a, which are arbitrary continuous functions of the coordinates within an arbitrarily chosen finite space at the limits of which they vanish. Then, the integration being throughout the space S, and the quantities g_{ab} remaining unchanged,

$$\delta\int L\,dS + \int\Sigma(a)K_a\delta x_a\,.\,dS = 0 \quad\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2),$$

where dS, an element of a four-dimensional extension x_1, x_2, x_3, x_4, replaces dx, dy, dz, dt, and K now represents the external force per unit of volume. The fundamentally important point of Einstein's theory consisting in the connection between the quantities g_{ab} and the corresponding coefficients g'_{ab}, resulting from an arbitrary substitution changing x_1, x_2, x_3, x_4, into other coordinates x'_1, x'_2, x'_3, x'_4, defined by the condition that $ds^2 = \Sigma(ab)g_{ab}dx_a dx_b$ should be an invariant, finds its expression in the fact that $L\,dS$, and therefore also $\int L\,dS$ is an invariant when we pass to another system of coordinates. The various equations of motion corresponding to those given by Einstein are derived very simply from (2). Electric charges moving under the influence of external forces in a gravitation field are then considered, and their motion and the electromagnetic field belonging to them determined, the density of the charge being assumed to be a continuous function of the coordinates. In Einstein's theory the electromagnetic field is determined by two sets, each of four equations, corresponding to well-known equations in the theory of electrons. The author considers one of these sets as the mathematical description of the system to which Hamilton's principle is to be applied, and derives the second set as the result of this application.

G. W. DE T.

721. *Motion of Particle on Surface of Smooth Rotating Globe.* **F. J. W. Whipple.** (Phil. Mag. 33. pp. 457–471, June, 1917.)—The free motion of a particle over a smooth rotating globe has not in the past received much attention, but the author considers that a knowledge of the motion of such a particle will prove a useful preliminary to a proper understanding of the more complicated motion which actually occurs in winds, where the air particles have other forces besides that of gravity acting upon them. After briefly dealing with the case of a particle on a smooth rotating sphere, the case of a globe having a "level" surface is considered. During the motion over the surface the relative speed remains constant. If the velocity is small so that variation in latitude is negligible the track is a circle and the period of the motion relative to the surface of the globe ½ cosec λ days (where λ = latitude). Where variations of latitude must be taken into account the general equations

are worked out, but before a complete solution can be found it is necessary to assume that λ is small throughout the motion. The equations are thus approximate only and must not be used for high latitudes. The solution then falls into three classes according as a constant C is positive, zero or negative. The value of C is governed by the initial motion and starting-point of the particle.

The results are illustrated by curves which show the motion of a particle given the velocity of 10 m./sec. over a globe having the dimensions of the earth. The first set of curves (C positive) give oscillatory paths backwards and forwards across the equator. In the second set ($C = 0$) after a looped path the particle approaches the equator asymptotically. In the third case (C negative) motion is confined to one side of the equator. An approximately circular path is followed but with a gradual drift to the westward.

J. S. Di.

722. *Periodic Irrotational Waves on the Surface of Deep Water.* **Rayleigh.** (Phil. Mag. 33. pp. 381–389, May, 1917.)—Burnside [Lond. Math. Soc. Proc. 15. p. 26 (1915)] has severely criticised Stokes' treatment of this question in which he uses series proceeding by ascending powers of the height of the waves, concluding that "these successive approximations cannot be used for purposes of numerical calculation" and further throwing doubt on the existence of permanent irrotational waves. Rayleigh had expressed scepticism in an early paper ["Sci. Papers," 1. p. 261], but subsequently [Phil. Mag. 31. pp. 45 and 558 (1895)] accepted their existence on the basis of later confirmatory evidence, and later on [Abs. 857 (1911)] shows that the method of the early paper could be extended so as to obtain all the later results of Stokes. These conclusions are confirmed by the further calculations of the present paper and the author considers that they warrant our accepting the existence of permanent waves of moderate height, though of course a strict mathematical proof of their existence remains a desideratum. He shows reasons for concluding that the numerical discrepancies which form the basis of Burnside's argument arise from the slow convergence of the series employed by Stokes. He considers the evidence sufficient to accept their convergence in the case of waves of moderate height, and if this be so, suggests that it is very unlikely that the case will be altered until the wave attains the greatest admissible elevation, when, as Stokes showed, the crest comes to an edge at an angle of 120°. G. W. de T.

723. *Initial Wave Resistance of a Moving Surface-pressure.* **T. H. Havelock.** (Roy. Soc., Proc. 93. pp. 240–253, May 3, 1917.)—The study of the water waves produced by the motion of an assigned pressure distribution over the surface has hitherto been limited to the steady state attained when the system has been moving with uniform velocity for a very long time. In his latest series of papers on water waves, Kelvin made an elaborate graphical and numerical study of cognate problems, and expressed the hope of applying his methods to calculate the initiation and continued growth of canal ship-waves due to the sudden commencement and continued application of a moving, steady surface-pressure. In the present paper, the author has not attempted any analysis of the surface elevation itself, but has proceeded directly to the calculation of the corresponding wave resistance. At present the wave resistance is known only for the steady state for certain localised pressure systems in uniform motion, and it seems desirable to attempt some estimate of the time taken to attain this state when we take into account the beginnings of the motion. The problem has been limited to the consideration of a system which is suddenly established, and is at the same instant set in motion with uniform velocity. A general expression is first obtained for the wave resistance as a function of the time. Next an exact solution is derived for a certain waveless system, and this solution is compared with the group approximation. Finally an approximate solution is given for certain systems which leave regular waves in their rear. A. W.

724. *Equilibrium of Rotating Fluids.* **B. Globa - Mikhailenko.** (Comptes Rendus, 163. pp. 700–703, Dec. 4, 1916.)—The paper is a brief preliminary summary of the solution of the following problem :—Given a fluid mass in the form of a hollow circular cylinder, rotating in equilibrium about its axis with given angular velocity ; to determine the nature of the laminæ of infinitely small thickness remaining constant along any generating line, of total mass zero, and which, when applied to the inner and outer surfaces of the cylinder, will give rise only to such deformation as will permit of the rotating fluid remaining in equilibrium. The existence is established of a series of bifurcation figures giving rise to a discontinuous series of new equilibrium configurations. G. W. DE T.

725. *Evaporation from Surfaces of Crystals.* **M. Knudsen.** (Ann. d. Physik, 52. 1. pp. 105–108, Feb. 15, 1917.)—Assuming that the atoms are regularly grouped in a crystal and held together by quasi-elastic forces, which are of different magnitude in different directions, we might expect evaporation from a crystal to take place in preferential directions. This view is not supported by experiments. The author mounts a crystal (sulphur, zinc, silver, stibnite) in such a way between a block of iron and a thin foil of Pt that a smooth crystal or cleavage face of 2 or 3 mm. diam. is exposed, suspends it by Pt-wires inside a sphere of glass, 6 cm. in diam., heats the crystal by the current through the wires and cools the sphere in liquid air. The suspension is such that the crystal lies in the spherical surface. The vapour condenses on the glass in a thin film apparently of uniform thickness, whilst a pit (0·15 mm. deep in the case of sulphur) forms in the exposed face which turns grainy. Not all the atoms in the surface seem to assume the vapour form at the same time, therefore, and the evaporation does not appear to be limited to preferential directions. The cosine law, which the author had shown to hold for incident atoms of Hg, Zn, Cd [see Abs. 371 (1909), 1317 (1911), 1357 (1916)], must thus hold also generally for atoms evaporating from a crystal, as otherwise there could not be equilibrium. H. B.

726. *The Shapes of Group Molecules forming the Surfaces of Liquids.* **I. Langmuir.** (Nat. Acad. Sci., Proc. 3. pp. 251–257, April, 1917.)—In a previous communication [Abs. 171 (1917)] the author advanced the theory that all the forces involved in the structure of solids and liquids are similar in nature to the forces causing chemical combination. From this point of view he now discusses the subject indicated in the title. The spreading of oil on the surface of water the author regards as being due to an affinity between the COO-groups and water. If only a limited amount of oil is placed on a large surface, the spreading ceases so soon as all the available COO-groups have come into contact with the water. According to this conception, pure hydrocarbons will not spread on water, as indeed is found to be the case. The theory also indicates that the hydrocarbon chains in the oils must be placed above the COO-groups on the surface, and in a homologous series, as the length of the chain increases the thickness of the oil film should also increase, while the area occupied by each molecule should

remain constant. This, the author finds, is what actually occurs. Other cases are also considered, and in the case of solutions the author concludes that in moderately concentrated solutions of all substances which strongly depress the surface tension the surface consists of a layer, one molecule deep, of the dissolved substance, and that there is never a transition layer in which the concentration varies progressively as we go farther from the surface into the solution. The amount of solute required to form the monomolecular layer can be calculated from Gibbs's equation, and the length and cross-sections of the molecules forming the surface layer may then be found. A. F.

727. *The Formation of Anticyclonic Stratus.* **C. K. M. Douglas.** (Roy. Soc. Edinburgh, Proc. 37. pp. 137–148, 1916–17.)—The clouds here termed stratus, which include those of the *st-cu* type, are found by observation from an aeroplane to have an adiabatic temperature gradient below them and a reversed gradient above them. Within the cloud the gradient is usually adiabatic, and there is considerable turbulence. On the north and east sides of anticyclones there is nearly always a layer of stratus or of haze with cloud patches. The height of the layer varies between 3000 and 6000 ft. It is pointed out that stratus may be formed by the adiabatic compression of non-homogeneous cloudy air, the layers of cloud where there is initially most free water present becoming less warmed than the layers above and below after the water has evaporated from these, and so giving rise to the reversed gradient above the remaining layer of cloud. A reversed gradient may also be formed at any layer above which there is a pronounced increase of westerly wind, this westerly current being normally warm and tending to raise the temperature at its level. By the use of a formula put forward by N. Shaw it is demonstrated that this is particularly likely to happen on the northern sides of anticyclones at any height where there is initially a smaller vertical temperature gradient than normal, the tendency being for this abnormality to become accentuated. J. S. Di.

728. *Classification of the Hydrometeors.* **G. Hellmann.** (Monthly Weather Rev. 44. pp. 385–392, July, 1916, and 45. pp. 13–16,, Jan. 1917.)—A classified list, with discussion, of the various phenomena of weather which owe their origin to the presence of aqueous vapour in the atmosphere, and which actually bring water to the earth in liquid or solid form. The phenomena are classified into three groups according to the mode of formation, as follows :—(1) Direct condensations of water-vapour at or near the earth's surface. These include dew, mist, fog, and "rain without cloud," as well as their solid equivalents. (2) Direct condensations in the free air (clouds, both of water and ice) ; and (3) indirect condensation of water in the free air. These are the precipitates falling from clouds, viz., rain, snow, soft hail (*Graupel*), hail, sleet, and glazed frost. R. C.

729. *A Correlation between Magnetic Storms and Rain.* **H. Arctowski.** (Comptes Rendus, 164. pp. 227–229, Jan. 29, 1917. Soc. Spettroscop. Ital., Mem. 6. pp. 33–34, March, 1917.)—Rainfall observations at Batavia and Greenwich are used to show an apparent relation between rainfall and magnetic storms, which suggests that the phenomena may be connected in some way, probably through the medium of solar activity. R. C.

730. *New South Wales Rainfall.* **D. J. Mares.** (Monthly Weather Rev. 44. pp. 393–395, July, 1916.)—This is a brief review of the annual and seasonal distribution of rainfall over New South Wales. The low land of the North-West forms the driest part of the State, the average fall varying from 6 to 12 in. per year. The fall gradually increases eastward with increase of height, 19 in. being the average for the Central-Western plain, and about 25 in. on the slopes. On the tablelands, still farther east, the average fall is 31 in. To the east of the mountains rainfall increases markedly, and varies from 34 in. in the South coastal region to 50 in. in the North coastal region. The max. average annual fall for any station in the State is 80 in. at Bilambil.

Rainfall is fairly well distributed over the four seasons, the maximum usually occurring in summer in the north, where monsoonal effects are pronounced, and in winter in the south, which experiences the effects of Antarctic depressions. Spring is the driest season everywhere. R. C.

731. *The Relation between Pressure-gradient, Wind, and Friction in Steady Motion.* **F. Åkerblom.** (Ark. för. Mat. Astron. och Fysik, Stockholm, 11. No. 18. [19 pp.], 1916.)—On the assumption that motion of the air near the earth's surface could be treated like the steady motion of a particle, Guldberg and Mohn developed simple equations connecting wind velocity with horizontal pressure gradient, latitude, air density, and friction. In forming the equations it was assumed that friction acted in a direction opposed to that of the surface wind. Comparison with observations, however, showed that the equations were inapplicable to surface winds in the interior of continents, that coastal winds conformed more nearly with them, while observations at a single station at sea gave satisfactory agreement with them.

The author introduced the conception of friction acting in a direction different from that of the surface wind reversed, on the ground that the upper wind, which affects the surface wind by friction as well as the ground, usually differs in direction from that wind. Comparison with observations in Europe, America, and over the North Atlantic give values of the angle between the direction of friction and the reversed direction of the surface wind which vary from 30° to 60° and are slightly greater over sea than over land. Over land the angle appears to show a maximum in the early afternoon and a minimum at night. R. C.

732. *Motion of the Air in the Lowest Layers of the Atmosphere.* **G. Hellmann.** (Preuss. Akad. Wiss. Berlin, Ber. 10. pp. 174–197, 1917.)—From measurements of the wind velocity at five different heights up to 258 metres above the ground at the German wireless telegraph station at Nauen, the law is deduced that wind velocities at different heights vary as the fifth roots of the heights. At 512 m. the velocity is twice that at 16 m. The diurnal variation of wind velocity at the surface with a maximum in the afternoon extends in winter only to a height of about 60 m. above the ground. Above that height the opposite type of variation is found, with a maximum in the night. The neutral zone between the two types is considerably higher in the summer, probably at about 300 m. [See Abs. 1212 (1914).] R. C.

733. *Viscosity of the Earth.* **H. Jeffreys.** (Roy. Astron. Soc., M.N. 77. pp. 449–456, March, 1917.)—The author has shown in a former paper [Abs. 288 (1916)] that the existence of the Eulerian nutation is incompatible with the explanation of the lunar secular acceleration on the basis of an "elastico-viscosity" of the earth, as assumed by G. H. Darwin. Such elastico-viscosity, represented by a stress-strain equation of the type $nS = F + 1/t_1 . \int F dt$, where S is the strain, F the stress, n a constant

proportional to the rigidity, and t_1 a constant, must certainly have played a large part in the past history of the earth, when in fluid or semi-fluid condition. Transverse earthquake waves might be accounted for on the basis of perfect elasticity, in the absence of the lunar and solar secular accelerations, and the author notes, as a point calling for further inquiry, that their observed ratio differs from the theoretical value. But both the continued existence of nutation and the earthquake waves may be explained on the basis of what the author calls "firmo-viscosity," represented by an equation of the type $n(S + t_1 dS/dt) = F$, suggested to him by J. Larmor. This gives a frictional term proportional to the strain, which appears highly probable, and under constant stress the strain approaches asymptotically the value F/n, returning to zero on cessation of the stress. There is therefore no permanent set, as in elastico-viscosity, whence the choice of the name firmo-viscosity, as implying, not weakness, but additional stiffness. Earthquake-wave observations show that this firmo-viscosity must be confined to a comparatively small portion of the earth's bulk, probably near the centre, and that nearly the whole earth may be regarded as perfectly elastic, except for forces with periods of a century or more, which will account for the nutation. It is found that the generally accepted value of the secular acceleration of the moon implies frequent small adjustments of the earth to the hydrostatic form during geological time. If there were no necessity to assume the present existence of tidal friction, these adjustments would not necessarily be required, as the moon might have attained its present orbit before the earliest known sedimentary rocks were formed. G. W. DE T.

734. *Live* aa *Lava at Kilauea.* **T. A. Jaggar.** (Washington Acad. Sci., J. 7. pp. 241–243, May 4, 1917.)—In a former paper [see Abs. 464 (1917)] the writer maintains, from measurement and experiment, that the Kilauea lava column is twofold, a main semi-solid incandescent body, or " bench magma," filling the Halemaumau pit shaft from side to side for an unknown depth, and a minor, shallow, liquid lava body, or "lake magma," which circulates through several small vertical shafts, these acting as conduits and sink-holes below a saucer 8 to 15 metres deep in the bench magma column, this being the well-known "lava lake." The lake magma exhibits a convectional circulation more rapid than that of the bench magma.

This paper contains a description of an adjustment of the latter which took place on March 20, 1917. The author examined some of the lava formed and found it to be of the *aa* or block type ; this was the first identification of actual *aa* under formative conditions in the Halemaumau pit. The *aa* was a heavy block lava consisting of the usual complete, scoriaceous, vesicular units in the talus, 5 to 30 cm. in diam., showing no fracture surfaces, and of reddish greenish brown colour. In the wall the rock is in places grooved vertically like scraped wax, being a steel-grey rough substance, while overhanging drip bodies are hard, scoriaceous, and quite like the block units. The material is nowhere ropy or membranous like pahoehoe, and has not the slightest resemblance to the crusts and overflows of the lake. It is very similar to the *aa* flow which was ejected from Mauna Loa in 1916. H. H. Ho.

735. *Earthquakes of Jan.* 29 *and Feb.* 20, 1917. **J. Young.** (Roy. Astron. Soc. Canada, J. 11. pp. 146–147, April, 1917.)—The earthquake of Jan. 29–30, 1917, was the largest ever recorded at Toronto. Preliminary tremors began on the 30th at 2h. 56·6m. G.M.T., and the secondary waves at 3h. 5·3m., indicating an earthquake centre about 7490 km. distant. These

were followed by larger waves, the principal part of disturbance occurring at 8h. 28m.–8h. 30m. At Victoria the maximum occurred 18·7 minutes earlier. The disturbance of Feb. 20 was probably submarine in the neighbourhood of West Indies; the swing at Toronto was over 25 mm., and occurred 17m. 44s. earlier than the disturbance at Victoria. Reproductions of the seismograms are given. C. P. B.

736. *Absence of scattering of Light in Space.* **H. Shapley.** (Nat. Acad. Sci., Proc. 3. pp. 267–270, April, 1917.)—It has already been shown from the evidence available that interstellar space, in the direction of the Hercules cluster, is free from the type of light absorption that modifies the colours of stars [Abs. 297 (1916.)] The present paper is devoted to an analysis of clusters in the Milky Way, and is summarised in a table showing the maximum, minimum, and average colour indices for each of the regions involved; also the computed parallaxes. The blueness of the faint and distant stars is clearly indicated, and is interpreted as showing the absence of differential light-scattering in interstellar spaces. C. P. B.

737. *Test for Einstein's Theory of Gravitation.* **F. W. Dyson.** (Roy. Astron. Soc., M.N. 77. pp. 445–447, March, 1917.)—According to Einstein's theory a ray of light grazing the sun's limb should be deflected. Photographs taken by Davidson with the astrographic equatorial at the solar eclipse of 1905 have been examined, but the results were not sufficiently accordant, and it is suggested that special arrangements be made to obtain photographs during the eclipse of 1919 May 29 for the critical analysis of the effect. A list of stars is included which will be available for instruments of the astrographic type, with the computed displacement that should be shown if the theory be correct. C. P. B.

738. *Position-Relationship between Spots, Flocculi, and Prominences.* **O. J. Lee.** (Astrophys. J. 45. pp. 206–212, April, 1917.)—Spectroheliograph plates taken at the Yerkes Observatory during the last 18 years have been examined to ascertain the degree of relationship in position between spots, flocculi, prominences, and filaments. The period covers almost completely the last maximum of solar activity and runs well into the present one. Out of 4086 prominences of all sizes which have been observed between + 45° and — 45° of solar latitude, only 236, or 5·8 %, occurred in the immediate vicinity of sun-spots. In the same region only 324, or 8 %, of the prominences occur with flocculi in which no spot was visible. This slender connection between prominences and spots and flocculi exists practically to the same degree for times of greater or less solar activity. Of the 78 filaments which were observed near the solar limb, 63 (81 %) showed connection with prominences. A considerable number of the large eruptive prominences occur either in unmarked regions of the solar surface or where the surface appears roughened. The general conclusion is that there is no ground for continuing the old belief that the prominences occur in close connection with sun-spots and flocculi. C. P. B.

739. *Effect of Haze on Measures of Solar Rotation.* **C. G. Abbot.** (Astrophys. J. 45. pp. 65–67, Jan., 1917.)—With reference to the suggestion by De Lury [Abs. 1880 (1916)] that variations in results from spectroscopic determinations of solar rotation may be due to the superposition, on the spectrum of a definite point of the sun's image, of the spectrum of scattered light from

the sun as a whole, observational evidence is brought forward to show that the dilution is very much less than the amount given by De Lury. From 1904–1907 at Washington, and from 1913–16 on Mount Wilson, the distribution of light along the diameter of the solar image was observed at various wave-lengths. Even at Washington the total deflection produced by sky radiation and all other causes was less than 1 % of the deflection at the centre of the sun's disc. This was done with sun high, at zenith distances less than 50°; possibly the haze effect might be much greater with the sun nearer the horizon. C. P. B.

740. *Variation in Solar Rotation.* **H. H. Plaskett.** (Astrophys. J. 45. pp. 144–147, March, 1917.)—The observations at the Dominion Observatory, Ottawa, on the solar rotation are analysed from the point of view suggested by De Lury [Abs. 1330 (1916)] that atmospheric haze might have an important bearing on the modification of the spectrum as photographed, and hence on the rotation measurements. Plaskett finds no evidence of such variable haze, and adds that precautions were taken so as to avoid observations on days when the haze would amount to 8 or 10 %. C. P. B.

741. *Determination of Solar Apex from Radial Velocities and Proper Motions.* **C. D. Perrine.** (Astrophys. J. 45. pp. 108–111, March, 1917.)—A former investigation having shown an apparent dependence of the position of the solar apex upon the sizes and parallactic signs of the proper motions of the stars [Abs. 1007 (1916)], the work is now extended to the derivation of apices calculated from proper motions of the same stars. It is shown that the position of the apex of solar motion depends upon the proper motions in right ascension of the stars used. The differences appear to be greatest in declination, and the effect is shown in the results both from proper motions and radial velocities. These differences in the declination of the apex appear to arise chiefly from the proper motions of the northern stars, and to be satisfactorily explained by the assumption that the parallactic displacement of the stars is systematically less in the northern sky. C. P. B.

742. *Two Applications of Jacobi's Integral.* **H. Jeffreys.** (Roy. Astron. Soc., M.N. 77. pp. 447–448, March, 1917.)—Jacobi's integral is employed in an analysis of the motions of small particles which, according to the theory of Gyldèn and Moulton, give rise to the counterglow by reason of the light reflected from them. It is shown that the luminosity as seen from the earth would be greatest at the point opposite to the sun, and thus affords confirmation of the theory [Abs. 314 (1916)].

One of the conditions of steady motion is that the average velocity at any point must be the same as if the whole system rotated like a rigid body. Using again the integral, it is shown that in the case of orbital motion in a resisting medium whose general motion is direct, retrograde satellites will experience more resistance than direct ones, and therefore approach their primaries more readily. Granting then that the attractions of the other planets produce no important effect on the secular changes in the orbits, the fact that the known retrograde satellites are all on the outside of their systems renders it unlikely that they have been captured by the action of a medium in a state of steady motion. C. P. B.

743. *Surface Currents of Jupiter*, 1916–17. **S. Bolton.** (Roy. Astron. Soc., M.N. 77. pp. 460–462, March, 1917.)—A table is given showing details of phenomena observed on Jupiter during the apparition of 1916–17 with a 26-in.

reflector, and a drawing indexed so that any feature can be readily recognised. The quickened rate of the equatorial current was quite abnormal, the period being 7·7 secs. shorter than during the last apparition (1915–16). The white and dark spots fringing the N. edge of the N. equatorial belt exhibited two separate rates of motion. With regard to the colour of the planet the author confirms the observations of Lowell and Antoniadi on the cherry-red hue of the belts and poles. C. P. B.

744. *Colours and Magnitudes in Stellar Clusters.* **H. Shapley.** (Mt. Wilson Solar Observat., Contribs. Nos. 115, 116, 117. Astrophys. J. 45. pp. 118–141, March, 1917. Abstracts.)—An introduction to a series of papers dealing with an extensive investigation of the magnitudes and colours of individual stars in globular and open clusters which has been undertaken at the Mt. Wilson Observatory. For the discussion the systems will be classified in three groups: (1) Globular clusters of the type of M 13 in Hercules; (2) Open clusters, like M 11, or M 67, or Præsepe; (3) Moving clusters, like the Taurus group, the Pleiades, or any cluster of stars showing a communal motion. The open clusters are almost all in the Milky Way, and symmetrically arranged with respect to it, while the globular clusters are widely distributed in galactic latitude and limited in galactic longitude, and are mostly in one hemisphere. In the second part of the paper a discussion is given of the results from 1300 stars in the Hercules cluster M 13. With respect to work by previous writers it is stated that the Mt. Wilson photographs show no nebulous material brighter than the twentieth magnitude; also that the channels which have been detected among the brighter stars do not appear among the fainter objects. The magnitudes are derived from two pairs of plates, made on different nights, and each consisting of one isochromatic and one ordinary plate. A certain number of stars near the centre are being further examined in relation to the Eberhard photographic effect, and 1049 magnitudes and colour-indices are then investigated, 495 being outside the central region. Of these 495 stars at a greater distance from centre than 1·9′, more than 17 % have negative colour-indices. This leads to the important conclusion that there cannot be appreciable molecular scattering of light in space. Another notable feature is the decrease of redness of the stars with decreasing brightness. This is opposite to the relation found for the stars in open clusters such as M 67 or the Pleiades or the stars in the sky at large. Five new variables have been found in the cluster during the course of the measurements. The third paper contains a catalogue of 311 stars in the cluster M 67. No negative colour-indices were found in this cluster. C. P. B.

745. *Colours and Magnitudes in Stellar Cluster* M 11. **H. Shapley.** (Mt. Wilson Solar Observat. Contrib. No. 126. Astrophys. J. 45. pp. 164–181, April, 1917.)—The new method of inquiry into the constitution of stellar clusters is applied to the rich open cluster M 11 in Scutum Sobieski. Discovered by Kirsch 235 years ago, this object has been observed by many workers, and references are given to these. Stratonoff published in 1899 a list of 861 objects with positions to the hundredth of a second of arc, and his comparisons with the results obtained 60 years earlier giving only negative results for the proper motions indicate the great distance of the stars involved. The present study is interesting on account of the cluster being in low galactic latitude and near the star clouds of the southern Milky Way. A catalogue is given showing photographic and photovisual magnitudes and colour-indices for 458 stars, based on four pairs of plates taken in 1915–16. It is concluded that there is no evidence of the existence of the highly concentrated background of faint stars that is typical of globular clusters, and the object is apparently a condensation of not more than 200 stars brighter than 14·5 magnitude on a rich background. No conspicuous difference in average colour or magnitude is evident between the centre of the cluster and the outer region. The similarity of the cluster stars to the non-cluster stars in the neighbourhood, as in the case of M 67, supports the view that open clusters are an integral part of the galactic system. C. P. B.

746. *Nature of Globular Clusters.* **C. D. Perrine.** (Observatory, No. 512. pp. 166–168, April, 1917.)—The centre of condensation of the globular clusters appears to be almost exactly in the same direction as the bright region of the Milky Way in Sagittarius and Ophiuchus, which is also the region of one of the "ellipsoidal vertices"; there are also indications that the globular clusters are at the same order of distance as the more remote portions of the Milky Way, and it appears as if these objects were members of our own system. An investigation of the clusters in the region of the two southern nubeculæ is in progress, from which valuable data are expected. The brighter of the constituent stars of globular clusters show a preponderance of stars of slightly earlier type spectra. C. P. B.

747. *Physical Interpretation of Albedo.* **L. Bell.** (Astrophys. J. 45. pp. 1–29, Jan., 1917.)—An introduction is given setting forth reasons for distinguishing between geometric, spherical, and specific albedo, after which the progress of work on planetary albedoes is traced from the first results given by Zöllner in 1874. The determinations of the sun's stellar magnitude are shown to require revision to bring the results up to the standard of modern photometry, especially in the matter of coefficients of transmission of colour-screens and the exclusive use of the rotating sector-disc for variation of luminous intensities. A discussion is given of the relation between the phase-angle and geometric albedo for small bodies having no atmosphere. On the question of the variability of small bodies it is found that this cannot be satisfactorily accounted for by local differences of albedo, the range being in many cases too great. [See Abs. 768 (1916).] C. P. B.

748. *Orbit of Spectroscopic Binary 2 Sagittæ.* **R. K. Young.** (Roy. Astron. Soc. Canada, J. 11. pp. 127–132, April, 1917.)—An investigation of the orbit of the spectroscopic binary 2 Sagittæ (Boss 4947 or H.R.P. 7369) has been made from data supplied by 44 spectrograms of the star obtained at the Dominion Observatory, Ottawa, with a single-prism spectrograph. The spectra of both components are visible on the plates, the secondary being much fainter than the primary. When not confused by the secondary spectrum the lines are fairly sharp and narrow. The period is given as 7·390 days, and eccentricity 0·05. C. P. B.

749. *Stellar Spectra of Class R.* **W. C. Rufus.** (Detroit Observatory Publ., vol. 2. Nature, 99. p. 172, April 26, 1917. Abstract.)—The stars of spectral type R show radiations of shorter wave-length than the ordinary fourth type (N) stars. Sixty-six stars of the class are now known, and ten have been studied in detail. The criterion for distinguishing the R class from N stars is the intensity of the continuous absorption in the ultra-violet, and the suggestion is made that these stars form a connecting link between those of solar type and those of type N. The radial velocities of the ten

R stars range from −49 to +25 km./sec. The average colour-index is 1·7, compared with 2·5 for the class N stars. C. P. B.

750. *Volcanic Production of Meteorites.* **E. Belot.** (Comptes Rendus, 164. pp. 395–398, March 5, 1917.)—The principle of limiting velocities is employed in the discussion as to the possibility of meteorites owing their origin to the projection of materials from active volcanoes on the moon or other satellites of the solar system. With a lower estimate of the minimum velocity (2·36 km./sec.) necessary for a body to have before it could escape from the moon's surface the suggestion is considered to be a possible one. C. P. B.

751. *Recent Measures of Companion to Sirius.* **R. Jonckheere.** (Observatory, No. 513. pp. 203–204, May, 1917.)—Measurements have been made during the period 1914–1917 with the 28-in. refractor at the Greenwich Observatory, in continuation of the series begun some years ago at the University of Lille. Comparisons are given with the results of Lee and Lohse. C. P. B.

752. *Spectroscopic Determination of Stellar Parallaxes.* **W. S. Adams.** (Ast. Soc. Pacific, Publ. 29. p. 279. Observatory, No. 513. p. 206, May, 1917. Abstract.)—A further list of 21 stellar parallaxes is given, all determined by the spectroscopic method. These are for stars whose distances have been measured by the ordinary method, and the agreement is very satisfactory. An interesting feature is the determination of parallax in the case of double stars independently for each component. Three examples are given, one being η Cassiopeiæ, and the closeness of the values for the components furnishes a valuable check on the work. C. P. B.

753. *Persistence of Auroral Radiation.* **V. M. Slipher.** (Popular Astron. 25. p. 274, 1917. Nature, 99. p. 193, May 3, 1917. Abstract.)—Spectroscopic evidence has been obtained of the permanent illumination of the night sky by auroral light. A large percentage of the light is concentrated in the radiation of the yellow-green line at λ5572. From June, 1915, to Nov., 1916, over 50 exposures were made at Flagstaff on different parts of the sky, and the characteristic line appeared on all the photographs. They showed that the light is more intense near the horizon, and possibly towards the sunrise and sunset portions of the sky. C. P. B.

754. *Eclipsing Variable S.S. Camelopardalis.* **R. J. McDiarmid.** (Popular Astron. 24. p. 668, 1916. Astrophys. J. 45. pp. 50–59, Jan., 1917. Paper read before the Am. Astron. Soc.)—The variation of this star was discovered by Miss Cannon in 1908, and it was announced as a variable of the Algol type with a photographic range from 9·8 to 11·0 mag. It was taken under observation at Princeton in 1913, and the visual range found to be 0·60 mag. The period is slightly more than 4·82 days. Differences are noted in the range from maximum to principal minimum (0·57 mag.), and to secondary minimum (0·15 mag.). The principal eclipse lasts for 21 hours, and is total for 7 hours; the secondary is annular. Details of the system are computed, from which it is deduced that it consists of a large red star of low surface brightness and a smaller white star of considerably greater surface brightness. Both stars appear to be ellipsoidal. The density of the larger is 1/200, and the smaller 1/12 that of the sun. C. P. B.

755. *Relation of Blue Stars and Variables to Galactic Planes.* **H. Shapley.** (Nat. Acad. Sci., Proc. 3. pp. 276–279, April, 1917.)—Continuing the study of stars in clusters, it is shown that an underlying symmetry is generally present in the distribution. In M 13 the 130 brightest stars of colour-class B show preference for the sectors containing the axis of symmetry. The same grouping is also exhibited by the Cepheid variables present in the cluster. Collateral evidence is also obtained in the case of the bright globular cluster ω Centauri. The results indicate that the discoidal structure exhibited by many nebulæ, star clusters, and our own solar system, may be a predominant feature of the structure of the stellar universe. C. P. B.

756. *Numbers of Stars in Hyderabad Astrographic Catalogue.* **R. J. Pocock.** (Roy. Astron. Soc., M.N. 77. pp. 432–437, March, 1917.)—A description is given of the method employed at Hyderabad in determining the diameters of the star images for the Astrographic Catalogue, and a discussion of the numbers of stars of different magnitudes in the total of 63,000 for the zone −17° Decl. The discussion affords evidence in support of the view of obscuration suggested by Turner, the discontinuities in this zone occurring between 6h. and 7h. R.A., and between 20h. and 21h. R.A. There also appears to be evidence of an increase of the galactic condensation as we proceed southwards. C. P. B.

757. *Colour Curve of XZ Cygni.* **M. B. Shapley.** (Mt. Wilson Solar Observat., Contrib. No. 128. Astrophys. J. 45. pp. 132–138, April, 1917.)—Ninety-five multiple exposure photographs of the variable have been measured, and the resulting values are plotted in curves showing differences between photographic and visual magnitudes throughout the period of 0·47 day. The colour changes suggest a change of spectrum from class A_0 at maximum to F_5 at minimum. Curves are given to show five aspects of Cepheid variability. C. P. B.

758. *Eclipsing Variable Stars, RV Ophiuchi and RZ Cassiopeiæ.* **R. S. Dugan.** (Princeton Observat., Contrib. No. 4. Nature, 99. p. 252, May 24, 1917. Abstract.)—RV Ophiuchi, of spectral type A, is found to be 2·03 mag. fainter at primary minimum than at maximum, the brighter component emitting five times the light from the fainter star. RZ Cassiopeiæ is also of spectral type A, and is 1·59 mag. fainter at primary minimum than at maximum. The smaller star emits seven times as much light as the larger, and its surface brightness is twelve times as great. C. P. B.

759. *Hind's Variable Nebula, N.G.C. 1555.* **F. G. Pease.** (Mt. Wilson Solar Observat., Contrib. No. 127. Astrophys. J. 45. pp. 89–92, March, 1917.)—Seven exposures on this nebula have been made with the 60-in. reflector at Mount Wilson since Dec. 1911, and a series of short notes are given showing the variation of the nebulosity. The nebula lies close to the irregular variable star T Tauri; the data available do not establish parallelism between the fluctuation of both objects. Spectra obtained by Adams show that the star T Tauri is of type Md with additional bright lines, and that the parallax is of the order 0·05″ to 0·10″. The bright lines of the spectrum appear to extend beyond the dark lines, and are evidently due to the surrounding nebulosity. There is evidence of very faint extended nebulosity filling the whole starless region about T Tauri, and such details of this as were seen on the photographs are indicated in a sketch. C. P. B.

LIGHT.

760. *A New Ultra-violet Photometer.* **F. R. Lankshear.** (Manchester Lit. and Phil. Soc., Mem. 60. 10. pp. 1–4, April, 1917.)—The optical system of a new sector photometer is described which overcomes the objection, generally common to other photometers, of intermittent exposures. This result is obtained by the use of three reflecting prisms in the path of the absorbed beam and a reflecting prism and sector in the path of the unabsorbed beam. The sector is so arranged that the light is continuous. A Baly tube can be used with the instrument, and there is the additional advantage that the image is focused on the slit of the spectrometer. C. S. G.

761. *The Abbe Refractometer.* (Nature, 99. p. 331, June 21, 1917.)—Attention is here drawn to an interesting point in connection with the design of the Abbe refractometer as made by Zeiss. It has been observed recently by users of the instrument that, owing to want of illumination, measurements cannot be made for liquids having a refractive index greater than 1·52. It appears that in the instrument as constructed a crown glass prism of low refractive index ($N_D = 1{\cdot}52$) has been substituted for the dense flint prism ($N_D = 1{\cdot}75$) used at first as the lower, or illuminating, prism. The contact surface of the prism is left unpolished, so as to scatter the light entering the liquid film. The process of wiping the surface to remove the liquid which has been examined results in a surface approximating to a polished face. Hence very little light can fall on the contact surface of the liquid and the upper prism at angles greater than the critical angle unless the lower prism has a refractive index greater than that of the liquid under test. Several such instruments have been rendered serviceable for the measurement of liquids of refractive index as high as 1·70 by replacing the illuminating prism of crown glass by a suitable dense flint prism. In using the refractometer for solid and plastic bodies it would be more convenient if the prism box were designed to open away from the operator. A. W.

762. *Transverse Displacement Interferometry.* **C. Barus.** (Nat. Acad. Sci., Proc. 3. pp. 360–365, May, 1917.)—Describes the production and use of a set of very fine and sharp achromatic fringes which appear in a displacement interferometer when a broad slit is used. As one mirror of the interferometer is moved gradually forward these fringes alternately appear and disappear becoming gradually enlarged in size. Their use in displacement interferometry is discussed at length, as well as the possibility of detecting the drag of the ether in a rapidly rotating body, should such drag occur. J. W. T. W.

763. *Displacement Interferometry in Connection with U-tubes.* **C. Barus.** (Nat. Acad. Sci., Proc. 3. pp. 334–339, May, 1917.)—Describes apparatus for an interference method of determining the difference of length of the columns of liquid filling the two limbs of a U-tube. The interferometer employed was that described previously [see Abs. 1522 (1915)]. It was found necessary to make the tubes 4 cm. in diam. in order to avoid curvature of the surface at the axis due to capillarity. In the case of tubes 10 cm. long the effect of a difference of temperature of about 0·1 deg. between the tubes should be easily observable by mere displacement, whereas a difference of less than

0·08 deg. would be equivalent to the passage of one interference ring. The use of the Jamin interferometer in a similar way is described in detail.

J. W. T. W.

764. *Fixed System of Grating Interference-bands.* **C. K. V. Row.** (Calcutta Math. Soc., Bull. 8. Part II. pp. 59–70, 1917.)—The original paper describing the author's investigation; a preliminary account has already been given [see Abs. 882 (1917)]. L. H. W.

765. *Formulæ for Calculation of Triple, Cemented, Anastigmatic Lenses.* **A. Kerber.** (Zeits. Instrumentenk. 37. pp. 45–58, March, 1917.)—The original pages should be referred to for the formulæ, tables, and diagrams of zonal errors; no abstract is possible. L. H. W.

766. *Units of Radiation and Illumination.* **H. E. Ives.** (Astrophys. J. 45. pp. 39–49, Jan., 1917.)—A series of suggestions are made for the standardisation of the terminology of radiation which has hitherto been rather loosely used by various writers. In illustration of the terms proposed, it is suggested that Kirchhoff's Law should read "The radial emission of any body, due to temperature alone, is equal to the product of the absorbing power of the body, by the radial emission of a black body, of the same dimensions, at the same temperature." Also for any body whose radial emission is due to temperature alone, the emitting power is equal to the absorbing power.

C. P. B.

767. *Minimum Radiation visually Perceptible.* **H. N. Russell.** (Astrophys. J. 45. pp. 60–64, Jan., 1917.)—The work by Ives [Abs. 838 (1915); 660 (1916)] is supplemented by more recent determinations of two factors in the investigation, viz., the diameter of the eye pupil, which has been shown by Stevenson to be about 8·5 mm. under conditions of comparative darkness, and the stellar magnitude of the faintest visible objects. This latter appears to depend largely on the diffused light of the sky, as the results obtained by H. D. Curtis show that it is possible to detect with the aid of a large screen stars more than a magnitude fainter than those just visible without the screen. C. P. B.

768. *Reflection Coefficients of Metals in Schumann Region.* **I. C. Gardner.** (Astrophys. J. 45. pp. 30–38, Jan., 1917.)—A knowledge of the reflective powers of various substances for regions in the extreme ultra-violet to λ1030 has been obtained by the vacuum grating method, using speculum metal as comparison in each case. Nine substances have been examined: Si, Au, stellite, Pt, Cu, Ni, Al, Ag, and steel. Throughout the range tested λ1640–λ1030, silicon is much the best reflector of the samples under test; at shorter wave-lengths silicon becomes less reflective than speculum metal. Platinum is very like speculum metal from λ1600 to λ1300, but for regions more refrangible than λ1030 it becomes much better. Silver is much inferior to speculum metal. C. P. B.

769. *Visibility Equation derived from Luminosity Equation.* **P. D. Foote.** (Washington Acad. Sci., J. 7. pp. 317–318, June 4, 1917.)—Derives mathematically from the luminosity equation found by Ives and Kingsbury [see Abs. 1252 (1916)] the visibility equation

$$V(\lambda) = Re^{-217\cdot 8/\lambda}\,\lambda 4 \sum_0^\infty \left(\frac{87180}{\lambda}\right)^n \frac{1}{n\,!\,(n-1)\,!}\,,$$

where $V(\lambda)$ represents the visibility and $R = Ae^{-1/a}c_1^{-1}$. J. W. T. W.

770. *Colour Temperature of Illuminating-gas Flames.* **E. F. Kingsbury.** (Frank. Inst., J. 183. pp. 781–782, June, 1917.)—Gives the colour temperatures of various gas flames under different conditions as to quality of gas and size of flame, and shows that the colour temperature of a flame is, within certain limits, dependent on its shape, size, position, and the composition of the gas. It also varies in different parts of the flame. J. W. T. W.

771. *Dyes as Sensitisers of Carbon Tissue and Gum Paper.* **J. C. Warburg.** (Phot. J. 67. pp. 169–171; Disc., 171–174, May, 1917.)—This process which has been worked out by A. A. Meisling is briefly as follows: The carbon paper is soaked in a very weak solution—1 : 10,000—of erythrosin. Meisling has a theory that the action of such dyes is that, when exposed to light, in the presence of gelatine, they liberate formalin which hardens the gelatine and makes it insoluble. The drawback of the dyes as used for sensitising the carbon tissue is that they will not act in a dry state. There are two ways of employing this method. The paper may be sensitised and dried, or it may be used fresh. The time of exposure—it is exposed wet—is, according to Meisling, certainly not more than for the ordinary carbon tissue, but these experiments appear to show that it is a little more. One of the great advantages of the process is that the dry paper appears to keep indefinitely. Before use it has to be wetted in just the same way as it is sensitised originally. It, therefore, would be quite possible to put the paper on the market dry and ready for use. The development is the same as for carbon tissues, but it is necessary to work at much lower temperatures. At 95° or 100° C. it is found that the whole image disappears. The most successful development is at about 84° to 86°, which is much lower than the temperature employed with ordinary carbons. After development the pink stain of the dye remains and that pink stain seems to vary. The means which Meisling recommends for removing it is to give the print one or two baths of 1 % nitric acid, then to hang it up, and dry without rinsing. It does not appear possible to rinse it because rinsing brings the colour back. When dry, one or two turns in spirits of wine in a dry dish removes the colour. The same process is applicable to gum prints, and in this case it is not necessary that the paper should be wet: it is enough if it is damp, and, according to Meisling, in the sun it can be printed dry. A. E. G.

772. *Molecular Refractivity and Atomic Interaction.* II. **L. Silberstein.** (Phil. Mag. 33. pp. 521–533, June, 1917.)—The paper is entirely mathematical and a continuation of a previous communication [Abs. 424 (1917)]. It is divided into four sections. I. deals with atomic interaction; II. treats of the refractivity of diatomic gases and establishes that neither the axial nor the transversal refractivity of the compound obeys the additive law. The real departure from additivity is, therefore, even more radical than has been asserted in the first paper. At the same time, all the free frequencies belonging to the molecule, those corresponding to axial as well as to transversal oscillations, differ from the atomic ones. None of the original frequencies, and, therefore, of the atomic bands, will remain in the absorption spectrum of the compound. In Section III the special cases of hydrogen, oxygen, and nitrogen are considered, and a comparison is included of results with those obtained from the kinetic theory of gases. The interaction theory of dispersion is found to be entirely independent of the kinetic radii of the atoms of hydrogen, oxygen, and nitrogen, and also of any concepts of size or shape of the molecules and of their component atoms, since in this theory the atom plays only, thus far, the part of an optical centre or point, which is converted by external agents into an electric doublet, and the molecule is a system of such points. Section IV is devoted to the case of nitric oxide. Further work is promised on the *rôle* of interaction in more dense aggregates of molecules, viz., in solid crystals. H. H. Ho.

773. *Refrangibility of Light of very small Intensity: A Supplement to the Quantum Theory.* **R. Gans** and **A. P. Miguez.** (Ann. d. Physik, 52. 3. pp. 291–307, April 3, 1917.)—For the quantum hypothesis it is of interest to know whether by any means it is possible for an oscillator of frequency ν to be set into vibrations whose energy is less than $h\nu$, *i.e.* less than the elementary energy-quantum ϵ.

The present work attacks this problem, the outline of the investigation being as follows :—

A glass lens refracts light in consequence of vibratory particles in the glass. If the source of light is so feeble that these particles, according to the electromagnetic theory of light, must vibrate with an energy less than a single quantum ϵ, and if, on the other hand, a particle can only have energy zero, ϵ, or 2ϵ, etc., then the oscillators would not be stirred by the feeble source of light in question : accordingly, the light would not be changed ; that is to say, the lens would be unable to refract this light. Full details of the experimental arrangements then follow, and the theory is worked out.

It is thus shown that the quantities concerned are of the following orders :—

Energy per oscillator : $U \leqq 7 \times 10^{-41}$ erg.
Frequency : $\nu_0 = 3 \times 10^{-15}$ per sec.
Energy-quantum : $\epsilon = h\nu_0 = 19{\cdot}6 \times 10^{-12}$ erg.
$\dfrac{\text{Oscillator energy}}{\text{Energy-quantum}}$: $\dfrac{U}{\epsilon} = 3{\cdot}6 \times 10^{-30}$.

It is thus concluded that an oscillator may possess a quantity of energy which is *much less than a single energy-quantum.* This result is in direct contradiction to Planck's first form of the quantum theory.

After further discussion it is considered that the hypothesis of quanta is only applicable to thermal vibrations.

It is finally stated that either only the second form of Planck's quantum theory is valid, or that the conception of energy elements has simply a statistical but no dynamical significance. E. H. B.

774. *The Theory of Anomalous Dispersion.* **Rayleigh.** (Phil. Mag. 33. pp. 496–499, June, 1917.)—In a previous note with the above title [see Abs. 1844 (1899)] the author has pointed out that Maxwell, as early as 1869, in a published examination paper, had given the appropriate formulæ, thus anticipating the work of Sellmeier and Helmholtz. The German writers were unacquainted with Maxwell's formulæ, which indeed seem to have been little known even in England. The author thinks it would be of more than historical interest to examine the relation between Maxwell's and Helmholtz's work, and the present paper is the result. It appears that the generalisation attempted by Helmholtz is nugatory, unless we are prepared to accept a refractive index in the dispersive medium that becomes infinite with the wave-length *in vacuo.* Maxwell assumes that every part of the ether is connected with an atom of other matter by an attractive force varying as the distance, and that there is also a force of resistance between the medium and the atoms varying as their relative velocity, the atoms being independent of each other. Helmholtz also introduces a dissipative force which differs from Maxwell's in that it is dependent upon the absolute velocity of the atoms instead of upon the relative velocity of ether and matter, while a more important difference is the introduction of an additional force of restitution proportional to the absolute displacement of the atoms. Helmholtz's formulæ are, however, found to be no improvement upon Maxwell's. The author concludes that the full development of these ideas requires the recognition of more than one resonance as admissible.

H. H. Ho.

775. *Pole Effect in Electric Arc.* **T. Royds.** (Astrophys. J. 45. pp. 112–117, March, 1917.)—Small displacements occurring in the wave-lengths of certain lines in the spectra of different parts of the electric arc under varying conditions were suggested by Royds to be due to vapour-density differences, but this phenomenon has been ascribed by other workers to differences of amplitude [Abs. 1651 (1915), 777 (1916), 130 (1917)]. Royds does not accept this, showing that whereas the positive pole is hotter than the negative, the displacements are in general greatest at the negative; also that in the sun's reversing layer, probably hotter than the arc, the displacement of lines unsymmetrical in the arc is in the direction opposite to that of the displacement at the poles of the arc. Experiments with alloys also lead to the conclusion that density is the prevailing factor.

H. G. Gale. (Ibid. pp. 142–144, March, 1917.)—Gale emphasises the fact that in the arc he and Whitney found the wave-lengths of the calcium lines identical at the centre of an arc with carbon poles soaked either with a strong or weak solution of calcium chloride, the exposure times varying as ten to one. Royds also finds the same wave-length for the green copper lines at the centre of an arc between pure copper poles and between poles of a 20% alloy of copper. He does not agree with Royds in considering a rise of temperature as the most effective way to increase amplitude of vibration, suggesting rather the velocity of impinging electrons and canal rays which depend more on potential gradients. [See also Abs. 1651 (1915), 777 (1916).] C. P. B.

776. *Metallic Spectra in Infra-red.* **C. F. Meyer.** (Astrophys. J. 45. pp. 93–102, March, 1917.)—Photographs of the infra-red arc spectra of Li, K, Ca, Ba, and Sr were obtained with a Rowland concave grating of 1 metre focus and 16,000 lines to the inch, the region covered extending from λ6400 to λ9600 in the first order. The lines found are tabulated, with comparisons with other workers' results. [See Abs. 57 (1908).] C. P. B.

777. *Spectroscopic Observations on the Active Modification of Nitrogen.* **V. R. J. Strutt.** (Roy. Soc., Proc. 93. pp. 254–266, May 8, 1917.)—The circumstances under which the various groups of bands in the spectrum of the nitrogen afterglow appear, have been reinvestigated, and the conclusions of the author's earlier papers [Abs. 979, 1624 (1914), 769 (1915)] have been modified in some important respects. There was some doubt as to whether the faint bands λλ6394·45, 6468·53, 6544·81, and 6623·52 really form part of the afterglow spectrum at all. As a result of the present investigation it has been decided that these bands do form a part of the afterglow spectrum. It is also found that the second positive group is entirely absent from the afterglow spectrum, and the β and γ groups only appear when oxygen-

containing gases are introduced into the afterglow, or are originally present in the nitrogen used. Using nitrogen that only gives the β and γ bands very faintly, it is found that oxygen or nitric oxide added to the afterglow brings in the β and γ bands with a certain relative intensity, which may be called the standard. Carbon dioxide gives greater relative intensity to the β-bands, and carbon monoxide to the γ-bands. If nitric oxide or nitrogen peroxide is introduced in sufficient quantity into the afterglow, the β and γ groups disappear, and a visually greenish continuous spectrum, not extending into the ultra-violet, is substituted. Nothing like this is observed with the other oxygen-containing gases. Nitric oxide in a blowpipe flame gives this same greenish continuous band, together with the γ, but not the β, group. Chemical tests show that, when oxygen is introduced into the afterglow, there is no detectable oxidation of nitrogen, and certainly not nearly enough to account for the β and γ bands, on the view that these are due to nitric oxide generated. No definite conclusion is reached as to the origin of the β and γ groups, except that they require the presence of both nitrogen and oxygen. A number of illustrative spectrograms accompany the paper.

A. W.

778. *Single-lined and Many-lined Spectrum of Mercury.* **T. C. Hebb.** (Phys. Rev. 9. pp. 371–377, May, 1917. Paper read before the Am. Phys. Soc., Dec., 1916.)—Franck and Hertz have shown that one of the necessary conditions to obtain the single-lined spectrum of mercury is that the Hg vapour should be bombarded by electrons having a speed equal to or greater than that produced by falling through 5 volts. They found the ionising potential of mercury to be 4·9 volts and were led to the relation $Ve = hn$, where $h = 6{\cdot}5 \times 10^{-27}$ erg. sec. and n is the frequency of the single-lined spectrum. McLennan and Henderson [see Abs. 1408 (1915), 565 (1916)] found they could get the single-lined spectrum with p.d. between 5 and 12·5 volts across the discharge, but not below 5 volts. With p.d. 12·5 volts or over they got the many-lined spectrum. The single-lined spectra of Cd, Zn, and Mg have also been obtained and their ionising potentials determined by applying the quantum relation $Ve = hn$.

The author examines the spectrum of Hg vapour and finds that the Hg arc can be made to strike at any p.d. across the electrodes of the discharge tube greater than 4·7 volts, producing the many-lined spectrum. After the arc has struck, it can be made to operate with p.d. as low as 3·2 volts, still producing the many-lined spectrum. This needs a special explanation for the production of the ions unless it is shown that the velocity of emission of electrons from the electrodes is sufficient to account for the discrepancy between the observed p.d. and 4·9 volts.

The single-lined spectrum can be obtained for all p.d.'s between 2·5 volts and 21·5 volts. To explain its production below 5 volts a large velocity of emission must be assumed, or else the idea that ionisation is necessary for the production of light must be abandoned. It is also shown that whether the many-lined or the single-lined spectrum is produced depends upon the density of the electronic discharge.

T. H.

779. *Single-lined and Many-lined Spectrum of Mercury.* **R. A. Millikan.** (Phys. Rev. 9. pp. 378–382, May, 1917.)—With reference to the so-called one-line spectrum of Hg vapour, the author has previously pointed out that the opacity of the vapour for λ2536 requires that the light of the wave-length which leaves a discharge tube can come only from the surface layer, while that of other wave-lengths can come from the whole volume. Thus with increasing volume excitation the relative intensity of these lines to λ2536 must increase. With weak excitation λ2536 might be enormously more intense than other lines, yet the others might be present but too weak to appear on the photographic plates with the exposures used.

He shows that from Bohr's theory a single-line spectrum is not to be expected at λ2536. It has been proved that when electrons are driven through Hg vapour there is inelastic impact at 4·9 volts, but very little ionisation until 10·4 volts. This means that at 4·9 volts an electron in the atom is merely displaced from one orbit to the next outer orbit; when it returns it emits the longest line of the series corresponding to the return to that particular orbit. λ2536 should thus be the longest line of a series (which it is) and none of the shorter wave-lengths should appear at 4·9 volts. But since the normal spectrum of Hg contains lines of wave-length greater than 2536 these must belong to orbits farther out than that producing λ2536, and these lines should always be produced with λ2536; for it is shown that if there are electrons in these orbits they must be knocked entirely out of the atom at potentials not greater than, and perhaps much less than, 5·5 volts. But even if there are no electrons in orbits outside that giving λ2536 as the longest line, this wave-length must act photo-electrically on surrounding atoms and the return of the detached electrons should be accompanied by all lines of series corresponding to outer orbits, which, according to hypothesis, are normally empty.

If the emission of light is due, not to formation of positive atom-ions, but to simple stimulation of neutral atoms by corpuscular impact, many lines would be expected to appear simultaneously. Hence λ2536 should not appear without lines of greater wave-length. These lines may be expected to be weak if there are few or no electrons in orbits outside that corresponding to λ2536, but should be present. The author believes that Hebb's work [see preceding Abs.] indicates that these lines are always present, their appearance in photographs depending, in a given discharge tube, upon the density of the exciting electron stream. It is only the shorter wave-lengths of a given series which should appear successively with increasing applied potential. The author comments upon Hebb's results on the starting-point of the Hg arc, and suggests an explanation. T. H.

780. *Fluorescence and Phosphorescence.* **F. H. Glew, J. S. Dow,** and **A. Blok.** (Illum. Eng., London, 10. pp. 72–88, March, 1917. Chem. News, 115. pp. 157–159, April 5, 1917.)—F. H. Glew describes the production of fluorescent and phosphorescent effects, such as chemi-, tribo-, and pyro-luminescence, and the stimulation of zinc sulphide by rays from radium. Crystals and gems and other materials may be rendered luminous under kathode-ray bombardment; many substances emit a transient glow after exposure to visible or ultra-violet light. A cylinder coated with zinc sulphide was rotated rapidly in front of a tungsten arc: the brightness of the surface most remote from the light was shown to be equal to several candle-ft. The rate of decay of the brightness of radium compositions varies according to the amount of Ra present; a diminution in brightness of 50 % in one year is not unusual, but one sample, containing 74 mgm. of Ra per gm. of composition, diminished by this amount in 24 hours. Radium produces gradual discolouration of glass. If glass so discoloured is heated it emits light and afterwards loses its discolouration, the emission of light indicating the release of stored energy. In general the discolouration is essentially a surface-phenomenon. **J. S. Dow** refers to the physiological effects observed at such low luminosities. The brightness of samples of luminous paints varies according to the angle subtended at the eye; radium preparations have commonly a brightness not far removed from that of moonlight (0·02 candle-ft.) and the initial brightness is approximately proportional to the Ra-content. Various applications of such paints are mentioned. **A. Blok** discusses the photometry of such substances and the difficulties resulting from the low luminosity and peculiar colour. In testing small tubes it is convenient to observe the material through a slit in the photometric screen. In the *discussion*, **A. L. Landau** showed a number of examples of fluorescence, including materials excited by a spark between iron electrodes, and effects produced by shaking tubes containing mercury in the rare gases. The distinction commonly drawn between phosphorescence (remaining after cessation of stimulus) and fluorescence (existing only while the stimulus is applied) is considered undesirable. **C. C. Paterson** described the method of testing luminous dials that has been adopted at the National Physical Laboratory. J. S. D.

781. *Law of X-ray Line Spectra.* **H. S. Uhler.** (Phys. Rev. 9. pp. 325–335, April, 1917.)—This paper differs from an earlier one on the same subject [Abs. 509 (1917)] in three respects: (i) it includes the wave-lengths of all the accurately measured lines of the K-series; (ii) it contains the results of more rigorous calculations; and (iii) it presents the material in greater detail. A critical examination is now made of the functional dependence of the X-ray lines of any one sub-series upon the corresponding atomic numbers.

It is shown that Moseley's law $\nu = A(N - b)^2$ does not satisfactorily represent the X-ray series over the entire ranges of wave-lengths now known. The formula $\nu^{1/2} = A + BN + C(D - N)^{-1}$—where A, B, C, and D are constants for any one sub-series—is proposed, and shown to reproduce the observed data within the limits of experimental error. The uncertainty pertaining to extrapolation of the series as far as hydrogen is discussed, and the tentative conclusion is reached that the X-ray lines of hydrogen, if they exist, probably have wave-lengths less than about 400 Å.U.

Attention is called to the fact that the series of natural numbers commencing with 1 is not the only arithmetical progression which may be used as the sequence of atomic numbers consistent with Moseley's "irregularities." A. B. W.

782. *High-frequency Spectrum of Tungsten.* **A. W. Hull** and **M[arion] Rice.** (Nat. Acad. Sci., Proc. 2. pp. 265–270, May, 1916.)—An interesting outline is given of the earlier work of Moseley, Malmer, Bragg, Rutherford, Barnes, and others, on this subject. Rutherford [see Abs. 1417 (1915)], using the coefficient of absorption method, measured the effective wave-length of the "end-radiation" for different voltages up to 180,000 and found that the minimum wave-length did not decrease continuously with increase of voltage, but approached asymptotically a limiting value of 0·172 Å.U. It is indicated in the present paper that the wave-lengths found by the spectrometer are much shorter, and do not appear to approach any limiting value. The shortest wave-length so far observed is 8×10^{-10} cm., or 0·08 Å.U. Reproductions of photographs are included in the paper. The wave-lengths of the lines are about 6 % less than would be required by Moseley's formula. Diagrams are given which show the ionisation current as a function of angle of incidence of the rays on the crystal, for five different voltages. There is no trace of

the lines at 70,000 volts, but at 80,000 they are clearly visible, and increase in intensity as the voltage increases. It seems probable that the lowest voltage at which the lines appear is the "quantum" voltage, *i.e.* that given by Duane and Hunt's equation—for the γ line, about 70,000 volts for tungsten.
A. B. W.

783. *Nuclear Charges of Atoms.* **F. Sanford.** (Phys. Rev. 9. pp. 383–393, May, 1917. Paper read before the Pacific Phys. Soc., California, Dec., 1916.)—Assuming, as seems very definitely established, that the Einstein photoelectric equation $Ve = h\nu$ applies to characteristic X-rays and their exciting kathode rays, it is shown that if the electrons which emit the X-radiation are revolving in orbits about a central positive nucleus, the charge of this nucleus and the orbital radius of the revolving electrons may be calculated from equations of the same form as Moseley's equations for the X-ray frequency. The nuclear charges, when computed, are found to be integral multiples of a primary charge which in the case of the K radiation is the nuclear charge of helium, and which for the β-lines of the K-radiation has a value of $8{\cdot}9 \times 10^{-10}$ e.s. unit. The van den Broek hypothesis is sustained to the extent that the nuclear charge is found to increase with the atomic number. It has previously been shown that the orbital radius calculated in this manner from the convergence wave-lengths in known spectral series agrees very closely with the atomic radius calculated from other considerations.

In the case of the nine elements for which both the K and L characteristic radiations are known, it is shown that the nuclear charges calculated from the two classes of radiation differ in every case by an integral number of electronic charges, so that this difference may be calculated from the equations $Q_K - Q_L = e(N + 5)$.

It is shown that the nuclear charges calculated from X-ray wave-lengths may also be calculated, within groups of similar elements, from the ionic charges calculated from the mobility of the ions in electrolysis and from the charges of positive ions given off by hot metals. It is thus possible to calculate the ionic mobilities from the X-ray wave-lengths, and *vice versa*.
A. B. W.

784. *Röntgen-investigation of Allotropic Forms.* **J. Olie, Jr.,** and **A. J. Bijl.** (K. Akad. Amsterdam, Proc. 19. pp. 920–922, 1917.)—This communication describes an investigation in which the work of Debye and Sherrer [see Abs. 1130 (1916)] is extended to the particular case of allotropic forms of the same substance. Debye and Sherrer were able, whenever the wave-length of the primary X-rays was known, to infer the crystal form of the material from the interference figure obtained through the rays falling on a bar of crystal powder or quasi-amorphous material. The authors have now considered the question, What will be the result when allotropic modifications of the same material are radiated by homogeneous X-rays? Photographs are reproduced showing the interference figures obtained when Cu-rays fall upon (1) a bar of compressed graphite, and (2) a bar of diamond powder. The interference figures of these two allotropic forms of carbon are quite different, indicating that this method can be successfully employed in many cases in which it is doubtful whether there is real allotropy, or where two materials that cannot be chemically separated are present side by side; also in those cases wherein which it is doubtful whether we have to do with the amorphous or the crystalline state.
A. B. W.

785. *Secondary Effects of X-rays.* **F. Voltz.** (Phys. Zeits. 18. pp. 185–186, May 1, 1917.)—In a paper bearing the same title [see Abs. 186 (1917)] the author has shown that certain peculiar secondary effects observed in the "fluormetric" measurement of the hardness of X-rays were attributable to the selective absorption of the emulsion. The results obtained by using fluorescent screens were appreciably influenced by the composition of the fluorescent material.

Subsequent experiments have been carried out with three kinds of screen: (1) Barium-platinocyanide screen, (2) an "Astral" screen, and (3) an "Ossal" screen. Remarkable differences in relative brightness are observed when the three screens are illuminated by X-rays of different penetrating power. A. B. W.

786. *Comparison of X-ray Screens.* **T. Christen.** (Phys. Zeits. 18. pp. 186–187, May 1, 1917.)—Supplementary remarks to a paper by F. Voltz [see preceding Abs.]. This paper is a critical review of the properties of three types of screen: "Astral" I, "Astral" II, and "Ossal." These screens are compared from the points of view of (1) durability, (2) fineness of grain, (3) brightness of image, (4) sharpness of image, (5) "contrast" between the different parts of the image. A. B. W.

787. *Stability of Lead Isotopes of Thorium.* **F. Soddy, A. Holmes.** (Nature, 99. pp. 244–245, May 24, 1917.)—These letters are a continuation of the discussion as to whether or not lead is the end-product of thorium. Holmes gives a table of lead-ratios, recalculated on the assumption that 85 % of thorium gives lead as a stable end-product. These recalculated ratios approach that of uranite much more closely than do the simple Pb/U ratios, and thus they support Soddy's suggestion better than might have been expected from analysis of thorium minerals. Holmes insists on the unsuitability of thorium minerals for age determinations. A. B. W.

788. *Stability of Lead Isotopes from Thorium.* **J. Joly.** (Nature, 99. p. 284, June 7, 1917.)—Soddy's view on this subject [see preceding Abs.] involves the disappearance from 20 kg. of thorite, of 150 gm. of unstable lead and its conversion into thallium. In the thorite there should be present 0·012 gm. of thallium per gm. of thorium. Such a quantity should be easily measurable and, if found to be present, would support Soddy's suggestion.

On the views advanced by Soddy the author finds difficulty in reconciling his observations on thorium haloes. A. B. W.

HEAT.

789. *Thermal Expansion and Compressibility of Liquids at Low Temperatures.* I. **W. Seitz, H. Alterthum, and G. Lechner.** (Ann. d. Physik, 49. 1. pp. 85–92, 1916.)—At low temperatures the properties of liquids should, in the author's opinion, show a tendency to approximate to those characteristic of solids, and this work was carried out to test this view. It is found that for isopentane and ethyl ether the expansion coefficient diminishes with the temperature down to —120°, the lowest temperature attained. The coefficient for methyl and ethyl alcohols decreases at first, reaches a minimum at about —40°, and increases again at lower temperatures. Carbon disulphide is found to behave in a similar way; the minimum here occurs at between —70° and —80°.

Determinations of the compressibility of isopentane, ethyl ether, methyl and also ethyl alcohol, and carbon disulphide were made at temperatures between 0 and —110° and at pressures up to 1000 atmos. As the pressure increases, the expansion coefficient's tendency to increase with falling temperature becomes much more marked than at atmospheric pressure.

II. **W. Seitz and G. Lechner.** (Ibid. pp. 93–115, 1916.)—In his second paper the continuation of the experiments is dealt with, the compressibility measurements being carried out with a different form of piezometer based upon that of W. Wahl [Abs. 1472 (1912)]. A third paper, dealing theoretically with the results, is to follow.
L. H. W.

790. *The Coefficients of Thermo-elasticity at Low Temperatures and the Hypothesis of Nernst.* **E. Ariès.** (Comptes Rendus, 164. pp. 593–597, April 16, 1917.)—The author first states certain expressions deduced from the differential equation of the free energy I, $dI = d(V - ST) = -S dT - p dv$, and then proceeds to deduce that at the absolute zero every isothermal transformation is at the same time adiabatic. From the latter proposition remarkable consequences are drawn with respect to the eight independent coefficients of thermo-elasticity E_T, E_S, h, l, a_v, C_v, a_h, C_p—viz. the coefficient of isothermal compressibility is equal to the adiabatic, Thomson's coefficient $h = (\partial T/\partial p)_S$ vanishes, and the heat of dilatation $l = T(\partial S/\partial v)_T$ not only vanishes, but the ratio l/T tends towards zero with T. The coefficient of dilation at constant volume, a_v, vanishes also. It is proved that $(\partial I/\partial T)_v = (\partial V/\partial T)_v = C_v = 0$ for $T = 0$; that is, the calorific capacity at constant volume is nil at absolute zero, whatever may be the pressure. From the differential equation of the potential H, viz. $dH = -S dT + v dp$, it is shown that $(\partial S/\partial v)_T$, $(\partial S/\partial p)_T$, $(\partial v/\partial T)_p$, and the coefficient of dilatation at constant pressure, a_p, vanish with T. Again $(\partial H/\partial T)_p = (\partial J/\partial T)_p' = C_p = 0$, for $T = 0$; that is the calorific capacity at constant pressure is zero whatever may be the pressure. The paper concludes with a brief discussion of Nernst's hypothesis.
H. H. Ho.

791. *A New Evaporation Formula.* **R. E. Horton.** (Eng. News-Record, 78. pp. 196–199, April 26, 1917.)—In 1802 Dalton deduced the formula $E = C(V - v)$, where E is the rate of evaporation from a liquid surface, V the vapour pressure corresponding with the temperature of the liquid, v the vapour pressure existing in the atmosphere at the time and C is a constant. The effect of wind was allowed for by varying the value of C. Later workers have usually introduced a factor of the form $(1 + kw)$ to allow for the wind speed w. According to the formula thus modified, the rate of evaporation increases indefinitely with increase of wind, whereas in practice a max. value is attained when the velocity reaches 15 to 20 miles/hour, and above this there is no further increase. The author, therefore, prefers to allow for wind by the introduction of an exponential factor, and deduces the equation $E = C[(2 - \epsilon^{-kw})V - v]$. Values of the coefficient $(2 - \epsilon^{-kw})$ may be read off from a graph thus simplifying the working. The formula is also applicable to the case of condensation. It will be seen that under certain conditions of temperature and humidity condensation will take place in still air, while there will be slight evaporation under the same conditions in a wind. This result has been verified in practice. The formula as stated applies to a small liquid surface. The latter part of the paper is devoted to a consideration of the case of a larger area where the evaporation from the leeward part will be hindered by the presence of the vapour given off by the part more to windward. The author states that it will in many cases be more accurate to calculate the rate of evaporation from a large water surface by means of the formulæ here put forward, than to rely on attempts at direct measurement with the ordinary type of evaporimeter. J. S. Di.

RADIO-ACTIVITY.

792. *Tension of Saturated Vapour at Low Temperatures and on the Chemical Constant.* **E. Ariès.** (Comptes Rendus, 164. pp. 477–480, March 19, 1917.)—According to results given in a previous communication [Abs. 525 (1917)] the free energy of a perfect gas and its entropy are expressed by the formulæ—

$$I = -RT \log v + cT - cT \log AT,$$

$$\text{and} \quad S = R \log v + C \log AT = -R \log p + C \log T + R \log R + C \log A.$$

By initial choice of conditions, the constant B disappears and there only remains A to be considered. This constant A characterises the nature of the body, and, following Nernst, is termed its chemical constant. The author shows that at very low temperatures the entropy S may be replaced by R, and a formula thereby evolved for the tension P of saturated vapour which will be more exact the nearer it is to absolute zero, $\log P = (C/R) \log T + (C/R) \log A + \log R - 1$. The author considers Nernst's formula, which introduces a negative term $-L_0/RT$, where L_0 is the latent heat of vaporisation at absolute zero, and he shows that L_0 is zero, while the entropy is the same for both liquid and vapour and equal to R. The only change during passage from one state to another at absolute zero is shown to be one of volume. If m be the ratio of the two specific heats of a perfect gas, the value of the chemical constant A is shown to be $(Ke/R)^{m-1}$, while $P = KT^{m/(m-1)}$, the latter formula being very important from an experimental standpoint. Certain deductions from van der Waals' equation are next dealt with and verified by means of the above formulæ. The whole work is claimed to be of the highest interest for the progress of molecular physics. H. H. Ho.

793. *On Heats of Vaporisation and Maximum Vapour Pressures.* **A. Leduc.** (Comptes Rendus, 164. pp. 494–497, March 19, 1917.)—The method previously described by the author [see Abs. 1170, 1171 (1911), 1066 (1912)] for calculating γ, the ratio of the two principal specific heats of vapours, assumes the expressions $(1/F)dF/dT$ and $L/T - d\phi/dT$ to have been accurately evaluated. Unfortunately there is only a small amount of reliable experimental data available which relates to the max. pressure F, the latent heat of vaporisation L, and the total heat ϕ. The author now proposes to collate the values of L and dF/dT for the same body although obtained in general by different experimenters, by the aid of the Clapeyron-Thomson formula, $L = (T/J)(u' - u)dF/dT$, which, when u' is replaced by its value deduced from the author's formula $MFu' = RT\phi$, becomes $L = \frac{RT^2}{JM}\phi\left(1 - \frac{u}{u'}\right)\frac{1}{F}\frac{dF}{dT}$. The empirical formulæ permit the calculation of ϕ and consequently of u' to an error of 1 or 2 thousandths in the most unfavourable case, and to ten-thousandths generally, *i.e.* with sufficient accuracy. The data of Young and Ramsay for ether are first considered and the calculated results compared with those obtained from Winkelmann's formula. It is found that the values of L at 30° and 50° are exactly those which would be obtained on the assumption that the saturated vapour of ether behaves as a perfect gas. Regnault and Perot's results are next discussed. In connection with discrepancies the author questions the purity and anhydrous character of the ether used by different investigators. Benzene is also examined, results being obtained at the boiling-point under atmospheric pressure in complete accord with those of Regnault. H. H. Ho.

794. *On the Equation of State of Water and of Ammonia.* **G. Holst.** (K. Akad. Amsterdam, Proc. 19. pp. 982–987, 1917. Supplement No. 41 f. to Comm. from the Phys. Lab., Leiden.)—In a recent investigation on the equation of state of methyl chloride and ammonia, it was shown that the sign of the coefficient C of Onnes' equation of state, $pv = RT(1 + B/v + C/v^2 + D/v^4 + E/v^6 + F/v^8)$, was different for the two substances, being negative for ammonia but positive for methyl chloride as for other normal substances. At that time the author opined that C would be found negative for other associating substances. He has now calculated B and C for water-vapour from Jakob's data and finds that for water, as for ammonia, C is negative, and increases strongly with decreasing temperature. A formula representing C as a function of the temperature cannot be calculated until further data are to hand. For the other coefficient, B, more data are available inasmuch as water, like ammonia, has a large dielectric constant, which is a temperature function; and the author assumes, with P. Debye, that the water molecule has an electric moment. For spherical molecules with an electric dipole at the centre, Keesom has calculated the coefficient B as a function of the temperature. The experimental values are now compared with Keesom's calculated data. As in ammonia, deviations show themselves at the lower temperatures (below 250° C.), and the radius and the dielectric moment can be derived for the water molecule when assumed to be spherical. The author finds that the dimensions of the molecule correspond as regards the order of magnitude with those determined in other ways. For that part of the dielectric constant which is due to the dipoles, the same law holds as given by Curie for the magnetic susceptibility of ammonia, but the correspondence is not so good for water. Whether deviations actually occur in water, as in magnetic substances, must be settled by further experiments. The author draws attention to the conclusions which follow from his calculations, for the determinations made by Guye of the molecular weight of gases from the weight of a litre under normal circumstances and the compressibility. These measurements have not always led to a satisfactory agreement between the molecular weight determined in this and in other ways, especially in the case of easily compressible gases. It follows from the calculations that for an accurate determination of the compressibility the measurements must be so arranged as to determine both B and C, and when it is not established in another way that a given gas behaves as a normal substance, the compressibility for that gas must be specially determined. The calculations demonstrate that the deviations from the law of corresponding states, which in various substances may be very important as regards the value of B, may be even greater for C, so much so that the sign for substances with and without dipoles may be different. The fact that for some gases including ammonia a correct value for the molecular weight was obtained by making use of the law of corresponding states must be regarded as accidental. It is not to be expected that at other temperatures an equally good agreement would be found. H. H. Ho.

795. *Computation and Measurement of the Complex Molecules of Some Vapours, according to the New Condensation Theory.* **L. Andrén.** (Ann. d. Physik, 52. 1. pp. 1–71, Feb. 15, 1917.)—Having reviewed the literature with special regard to the Problems of Complex Molecules [Heidelberg Akad., Ber. 29. 1914; see Abs. 1446 (1915)] of P. Lenard, the author working with Lenard describes experiments made with vapours (water, ethyl alcohol, benzene) in a gas (air, carbon dioxide, hydrogen) in two expansion apparatus after C. T. R. Wilson. Two spherical expansion chambers were used, one of 60, the other of 260 cm.^{3} capacity; into the liquid contained therein penetrates the negative electrode (Pt wire), while the positive electrode (Pt disc) is suspended above the liquid. The very careful earthing of these electrodes is essential for experiments in which there is not to be any electric field, because very small p.d.'s affect the results; this may account for discrepancies between the results of Donnan and of Przibram. In a series of experiments the same volume of gas mixture is used for successive expansions after intervals of 3 or 4 mins. The number of drops formed is counted directly when there are not more than 10 drops in the field of view, which is illuminated by the beam from an arc lamp filtered through $CuCl_2$ and green gelatine. Or the centre of the sphere is alone illuminated by the aid of two stops at right angles to one another (N up to 3000 drops). Or the rate of fall of the drop is observed, their size calculated after Stokes-Millikan, and the value of N deduced from this and the mass of condensed vapour; this latter method was checked by diffraction-ring observations; the two methods agreed in the small and large apparatus, and the radii of the water-drops were never below $2{\cdot}2 \times 10^{-4}$ cm. The temperatures went down to $-35°$ sometimes. Lenard and Ramsauer having found that radiations acting upon vapours always accidentally present in the air (from the cotton-wool and rubber tubing *e.g.*) gave rise to the formation of complex molecules (H_2O_2, O_3, etc.), the materials and apparatus were carefully cleaned (by heat, cold, absorption, etc.). The series of experiments were conducted in the absence of any electric field; with electric field up to 380 volts/cm.; by increasing the never absent radio-active radiations of the atmosphere and earth with the aid of pitchblende and of weak and strong radium preparations, first with water-vapour and air. The experiments with CO_2 as gas gave much the same results. When the gas was hydrogen, the results differed from those previously obtained when the small sphere was used, but agreed again when the large sphere was applied; Wilson's condensation chamber, it is pointed out, was still smaller than the author's small sphere. Alcohol was tried mixed with air and with hydrogen; benzene only in air mixtures. The general conclusion drawn is that the ordinary condensation by expansion depends mainly upon the formation of electrically neutral complex vapour molecules and their size and surface tension, and is hence independent of the gas containing the vapours, whilst the electric carriers (ions) play only a secondary part. The formation of non-electric nuclei is a function of the vapour; the presence of traces of foreign vapours has no influence, provided chemical reactions (due to radiations) be excluded; the nuclei consist hence of complex polymerised vapour molecules. In addition to these non-electric nuclei there are electric carriers of both polarities, due to the radiations (terrestrial and atmospheric); they make up perhaps 1 % of the whole nuclei and consist predominantly also of vapour molecules. In size the nuclei differ with the nature of the liquid (vapour); but there is no discontinuity between the mists and the drops of a vapour, and the two types of condensation cannot be differentiated by definite expansion values. The electric carriers are always the largest nuclei; their number naturally depends also upon the gas; their number 900 (no external field) would correspond to the 0·4 carriers per sec. per cm.^{3} assumed to account for the very small residual conductivity of the air. There are, further, when the supersaturation degree is five or more, some very large non-electric nuclei (0·1 % of total number) due to the chemical reactions caused by the terrestrial radiations (H_2O_2, O_3, etc.). By far the greater number of non-electric nuclei are, however, small in size and consist of complexes of only a few (2 or 3) molecules; their number, determined for each vapour at ordinary temperature, is: water $1·9 \times 10^{-11}$, ethyl-alcohol $2·5 \times 10^{-11}$, benzene $0·8 \times 10^{-11}$ per cent. of the total vapour molecules present, which would correspond to about 100,000, 340,000, 190,000 molecules per cm.^{3}. These non-electric molecules are characteristic for each vapour. Exposure of the vapour-gas mixtures to β and γ radiations further increases the size of the nuclei, and thus the numbers of molecules per nucleus to 8, for water, and 6 for alcohol, and increases also in particular their number very much, in accordance with the radiation intensity. Lenard's theory supplements Kelvin's by adding a term depending upon the ratio of the portion of the drop surface from which evaporation can take place and upon the surface tension which varies with the radius and the thickness of the liquid shell. It also differs from J. J. Thomson in so far as with increasing expansion a supersaturation is said to be reached at which all the nuclei are condensed; the total number of nuclei in water vapour (no external field) seems to be limited to 10^5, as stated. H. B.

796. *Propagation of Flame in Acetone-Air Mixtures.* **R. V. Wheeler** and **A. Whitaker.** (Chem. Soc., Trans. 111. pp. 267–272, April, 1917.)—The authors investigate the industrial conditions under which vapours of inflammable liquids become explosive in conduits, etc., and the speed of propagation of the flame. For mixtures of acetone and air the higher and lower inflammability limits were determined in tubes of 2·5, 5, 10 cm. diam., 60, 150 75 cm. in length, for horizontal, downward and upward propagation of flame. Above 5 cm. the diam. influences the limits but little, and it is concluded that in large pipes of 60 cm. diam. the limits would be 2 % and 10 % of acetone vapour for horizontal propagation. The speed of propagation was determined for the "uniform movement" of the flame, which occurs only in tubes of small diam.; in the 2·5-cm. tube this speed attains its maximum of 96 cm. per sec. for 5·5 % of acetone. From the results of previous experiments with methane and air [see Abs. 198 (1915)] it is concluded that this speed would be 2·5, 3, 3·5 times as great for pipes of 30, 60, 90 cm. diam. Owing to the solubility of the acetone vapour in water, glycerol, brine, etc., the acetone mixtures have to be stored over mercury, and the apparatus must be kept thoroughly dry. H. B.

797. *Influence of Pressure on the Ignition of a Mixture of Methane and Air by Impulsive Electrical Discharge.* **R. V. Wheeler.** (Chem. Soc., Trans. 111. pp. 411–418, May, 1917.)—In a recent paper [Abs. 402 (1917)] an account was given of experiments made to check the observation by Thornton that the ignition of a mixture of methane and air by the impulsive electrical discharge proceeds *per saltum* as the pressure is changed. Lack of the requisite apparatus prevented at that time the investigation at pressures above atmospheric, but these experiments having now been made are found to differ in two essential respects from Thornton's. A diagram representing Thornton's results is shown in which there are not only well-defined "steps," but it is seen that when the pressure of the mixture is increased above 2000 mm. the direction of the stepped curve is reversed. The author has been unable to confirm Thornton's remarkable result of decreased ignitibility of a given mixture as its pressure is increased. An attempt made to use one of the explosion vessels that had been employed for the work at pressures less than atmospheric so as to make the results directly comparable, failed owing to the spark-gap being too great. A new explosion vessel with a spark-gap of between 0·25 and 0·5 mm. was therefore employed, the electrodes being of Pt instead of nickel. This reduction in the spark-gap enabled a secondary discharge of less intensity to pass, whilst at the same time, owing to the decreased length of the sparks, a greater intensity was required for ignition of the mixture. Thus ample margin was obtained between the minimum sparking-current and the minimum igniting-current. In the author's observations lies a possible explanation of the apparent increased difficulty of ignition with increased pressure of the mixture recorded by Thornton, the suggestion being that his records disclosed in reality the increased difficulty of passage of the discharge with increased pressure of the gas. H. H. Ho.

798. *The Virial Hypothesis and the Theory of the Brownian Movement.* **P. Frank.** (Ann. d. Physik, 52. 8. pp. 823–832, April 8, 1917.)—The virial hypothesis is one of the oldest explanations of the average behaviour of mechanical systems during prolonged periods of time. Since its presentation by Clausius it has been chiefly employed in the kinetic theory of gases for the establishment of the equation of state. Otherwise the virial hypothesis has played a very restricted *rôle*. Recently Langevin [Abs. 828 (1908)] has given a very elegant proof of Einstein's formula for the average areal displacement of a Brownian particle, which depends upon a very similar assumption to that utilised by Clausius for the derivation of the virial hypothesis. Langevin's result, while admittedly skilful, has been regarded by many physicists as not sufficiently rigid, and the present author here demonstrates that a fundamental relationship exists between the virial hypothesis and the Brownian movement. Langevin's result is therefore established. For this purpose the virial hypothesis is applied to movements which are no longer stationary, as is the case in the kinetic theory of gases. Stationary is described as the movement of a system when the coordinates and velocities of the material points always remain between finite limits and are independent of the time. After first establishing the validity limits of the virial hypothesis, it becomes apparent that important phenomena are no longer to be ascribed to Brownian particles on this hypothesis, and the author attempts to evolve a valid generalisation. In conclusion a physical interpretation of the virial idea is discussed.

H. H. Ho.

799. *Criticisms of Recent Monatomic Gas Theories.* **H. A. Lorentz.** (K. Akad. Amsterdam, Proc. 19. 4. pp. 787–751, 1917.)—The theories in question, though differing widely, agree in seeking, on the basis of the quanta theory, to determine the entropy S in terms of the volume v and the energy E, whence, from thermodynamic relations, the temperature T and the pressure p can be similarly determined, the equation of state found, and the specific heats determined. For an ideal monatomic gas, classical thermodynamics leads to the formula $S = kN(\log v + \frac{3}{2}\log E) + a$ ... (1), where N = number of molecules, k = Planck's coefficient, and a is an undetermined constant; and it is then inferred that $pv = kNT$, $E = \frac{3}{2}kNT$...(2). The new theories assign a definite value to S, either by a, which Nernst has called the *chemical constant* of the gas, taking a definite value, the equations (2) remaining unchanged, or by the replacement of (1) by a more complex formula, involving changes in the equations (2). In all cases S satisfies Boltzmann's equation $S = k \log W$, where W is the probability of the state considered. Generally speaking, there can be no doubt of the validity of this, one of the most important equations of modern physics, though difficulties may arise with regard to the methods used to determine W.

Defining the state of a gas in the usual manner in terms of the coordinates of the N molecules and the components of their momenta, regarded as the coordinates of a point in a 6N-dimensional space R_{6N}, an idea of the probability of different states may be obtained by supposing the state to be determined by drawing numbered slips of paper in such manner that a slip is drawn for each molecule successively, the number on the slip indicating the place and state of motion of the molecule by its coordinates in a six-dimensional space R_6. The slip will then indicate the point in this extension which represents the position and motion of the molecule, or, as we may say, its place in R_6. Planck introduced the *quantum* concept by supposing the space R_6 to be divided into equal finite elements of magnitude G, and the only question determined by the lottery was in which of these elements any molecule is to be placed. All molecules in any given element G he supposed uniformly distributed over the extension G, so that the position of any molecule in its element G is not determined by any consideration of probability. On these suppositions he obtained an expression which he considered not merely as proportional, but as equal, to the probability, leading to a value of the entropy free from any additive constant. His reasoning may be expressed thus:—Let $\Delta v_1, \Delta v_2, \ldots \Delta v_{N-1}$ be small elements of volume, each in the neighbourhood of one of the molecules $M_1, M_2, \ldots M_{N-1}$, in such a way that Δv_1 has the same position with respect to M_1 as Δv_2 with respect to M_2, etc. Then it might be that the element G with which we are concerned in the case of the Nth molecule consists of the volumes $\Delta v_1, \Delta v_2, \ldots \Delta v_{N-1}$ taken together and combined with certain intervals for the momenta; if this were so, G would really be proportional to $N - 1$, and therefore to N, which latter is easily seen to be essential.

Planck has failed to attach any physical meaning to his elementary domain G, nor does he show why finite intervals should be introduced into our considerations of probability, but possibly the latter might be accounted for as arising from mutual action between the molecules. But a far more fundamental objection is that if the distribution of the molecules over an element G is not to be determined by probability, then if $\Delta v_1\, \Delta v_2, \ldots \Delta v_{N-1}$ must be considered as constituting a single volume-element, the position of the Nth molecule will not be determined by our lottery. This can hardly be admitted; whether the Nth molecule will lie near the first or any other of the molecules already present must certainly be considered as something accidental. Moreover, the above reasoning applies only to places near one of the $N - 1$ molecules, and in gases of small density these places form only a small minority of all those that may be occupied by the Nth molecule.

Planck points out that in all probability G will be connected with the constant h which he has introduced into the theory of radiation, and which, when multiplied by the frequency, determines the quantum of energy characteristic of a vibrator. The dimensions of h show that, if so, G must be proportional to h^3. Before Planck, Tetrode had calculated the entropy of a gas in a similar way [see Abs. 1889 (1912)], defining G in terms of the constant h by the relation $G = (\omega h)^3$, where ω^3 is a constant to be determined later on, so that his elementary domain does not depend on N. He arrives at an expression for S nearly identical with that obtained by Planck, free from an additive constant, and which really fulfils the condition that S shall become n times greater when N, l, and E do so. But the arguments are open to the following objections:—Planck and Tetrode both make use of the consideration that the "thin layer" of the space R_{6N}, corresponding to a given value of v and to energy values comprised between E and $E + dE$, will have a definite magnitude proportional to dE, say ΩdE. Then, putting W proportional to Ω, Boltzmann's equation leads to the expression (1). Ω can be evaluated in terms of E, N, and the mass of a molecule for a cube of unit edges parallel to the axes of coordinates in R_{6N}. Planck obtains his definite value for S by making G proportional to N, the objection to which has been pointed out, while Tetrode attains the same object by dividing the expression for Ω by $N!$, a procedure for which the author can see no physical reason.

The *quanta* hypothesis has been used in quite a different way in a later paper by Tetrode [see Abs. 1013 (1913)], by Lenz in a communication by Sommerfeld (Vorträge, Wolfskehl Kongress, p. 125), and by Keesom [Abs. 288 (1914), and K. Akad. Amsterdam, Proc. 17. p. 20 (1914)]. Following Lenz, for example, it is assumed that the ordinary theory of stationary sound waves is applicable to a cubical enclosure with edges of length l, from the waves of length $2l$ down to a minimum length λ_0, so chosen that the number of modes of motion is equal to 3N, the number of degrees of freedom of the system of molecules. Following Debye in his theory of the specific heat of solids, in cutting off this sound spectrum at the wave-length λ_0, he follows him also in assuming the energy distributed in quanta, the quantum proper to each mode of motion being taken to be $hv = hc/\lambda$, where c is the velocity of sound in the gas, assumed constant for all wave-lengths. The entropy is then determined by probability considerations. The present author observes that an original state of molecular rest, from which all other modes of motion are deviations, can be imagined for a solid; and if the original energy be taken as zero, then the total energy of all co-existing modes at any time, if of sufficiently small amplitudes, will be equal to the sum of the energies of the separate modes. But it does not seem legitimate to ascribe the energy of the internal motions to a system of vibrations whose laws are deduced, in the case of a gas, on the assumption of a molecular motion necessarily antecedent to the vibrations themselves—for from this molecular motion the gas derives the elasticity which makes the vibrations possible. Now, the ordinary stationary sound-wave theory only fully applies when the wave-length is *very* great compared with the mean free paths of a molecule, and when they become comparable there is no longer pressure between different elements of volume, but intermixture, and so the waves must cease to exist long before Lenz's lower limit λ_0 is approached—for λ_0 is but little greater than the molecular distance, of which

S may be a considerable multiple. Sommerfeld attempted to meet this difficulty by observing that at high temperatures Lenz's formulæ agreed with the equation of the ordinary theory, while at low temperatures these formulæ show that the energy concentrates increasingly in the modes of large wave-length; but the present author shows by a calculation that it is only at very low temperatures indeed that the greater part of the energy will have shifted to waves greatly longer than λ_0. Thus, for He of density corresponding to 0° C. and a pressure of 1 atmo., even at the extremely low absolute temperature $T = 0{\cdot}22$, half the energy still belongs to modes of motion with wave-lengths less than $4/3 \, . \, \lambda_0$, *i.e.* less than the mean molecular distance, and therefore far less than S.

In conclusion, the author points out that Tetrode has found by observation the chemical constant of the monatomic vapour of mercury, and hence derived the value 1·05 for his coefficient ω. Calculating this on the lines of Tetrode's theory, and using his observed data, the author obtains the value 0·7, as close an agreement as could be expected if his theory were accepted. But in the course of the calculation the undetermined constants in the entropies of the true states of the mercury are somewhat arbitrarily fixed on the basis of apparently conflicting theories, and, further, the procedure is in part inconsistent with Boltzmann's theorem. The author therefore observes that though the value obtained for ω, if not quite accidental, pleads in favour of applying the *quanta* theory to the problem of vaporisation, yet the way in which this application has been made requires further explanation and justification. G. W. DE T.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

800. *An Aspect of Ohm's Law.* **E. Brylinski.** (Rev. Gén. d'Él. 1. p. 808, May 26, 1917.)—If E be the e.m.f. between the ends of a cylindrical conductor, Ohm's law gives us $E = \rho l(I/S)$, where l is the length and S the cross-sectional area of the conductor. If we suppose the conductor replaced by a dielectric we have $E = Hl$, where H is the strength of the field. Hence $H/\rho = I/S$. If ϵ be the magnetomotive force, we have $\epsilon = 4\pi I$. Owing to the reciprocal relations between magnetism and electricity we may suppose that ϵ is due to the variation of the electric flux of induction BS in the conductor and thus we may write $\epsilon = \partial/\partial t . (BS)$. If we suppose the ends of the conductor covered with equal and opposite layers of electricity $\pm Q$, then $Q = SB/(4\pi)$ and thus from our preceding equations $I = S/4\pi . \partial B/\partial t = \partial Q/\partial t$. This equation shows that we may regard the current as due to the variation of the quantity Q of electricity—a theory now generally admitted. In the electron theory Q has a real physical significance and the electric induction density B is simply a mathematical conception. A. R.

801. *The Electrodynamic Wall Problem.* **L. Roy.** (Comptes Rendus 163. pp. 608–611, Nov. 20, 1916.)—Given a conducting dielectric plane wall of uniform thickness, separating two non-conducting dielectrics or perfect conductors, the three media being homogeneous and isotropic, and either magnetic or not; to determine everywhere the vector potential, and hence the electrodynamic field, at any time, resulting from given initial conditions. The author solves the problem for initial conditions expressible as a function only of the coordinates perpendicular to the plane of the wall. G. W. DE T.

802. *The Electrodynamic Wall Problem and Condenser Leakage.* **L. Roy.** (Comptes Rendus, 163. pp. 703–705, Dec. 4, 1916.)—The author shows that the formulæ obtained in a previous paper [see preceding Abs.] lead to a solution of the problem of condenser leakage without the usual assumption that the effects of electrodynamic induction may be neglected, and that this solution is rigorously exact throughout the discharge. G. W. DE T.

803. *Protector against Hail of Marcillac at Chenavari (Ardèche).* (Rev. Gén. d'Él. 1. pp. 819–820, May 26, 1917.)—Wooden poles are mounted upon an eminence of 508 m. They carry flat iron aigrettes, earthed by iron bands, connected underground to iron perforated pipes filled with coke. The poles are arranged in polygon form, the diameter of a circle intersecting the position of the poles being about 90 m. A pole is planted also at the centre. The aigrettes are all joined together by barbed wire. There are 9 poles. The area covered is about 6000 sq. m. An additional earth is obtained at a small spring. Evidence is given of the diminution of hailstorms and of lightning discharges effected by this installation. But it is not stated over what area protection is afforded in this particular case. E. O. W.

804. *Identity of the Normal and Selective Photoelectric Effects.* **R. A. Millikan** and **W. H. Souder.** (Nat. Acad. Sci., Proc. 2. pp. 19–24, Jan., 1916.)—Contrary to the conclusion arrived at by Fredenhagen, Küster, G. Wiedemann, and Hallwachs, that the presence of a gas is a necessary condition for the appearance of photoelectric currents in potassium, the authors find that this is only true for the longer wave-lengths, the photoelectric effect at about 250 $\mu\mu$ being unaffected by any process of eliminating gas from the surface, either by making fresh cuts or by successive distillation. It is very difficult, if not impossible, to draw a distinction between the normal and selective effects, the latter being really nothing but the normal effect taking place in the neighbourhood of an absorption band, where a particular frequency predominates. The only condition for the copious emission of electrons is the coincidence of an impressed frequency with a natural frequency. The authors show in detail that in lithium, at all events, all distinction between the normal and selective effects disappears.

E. E. F.

DISCHARGE AND OSCILLATIONS.

805. *Explosive Potential in Carbon Dioxide at High Pressure.* **C. E. Guye** and **C. Stancescu.** (Comptes Rendus, 164. pp. 602–605, April 16, 1917.)—The explosive potential in a gas which follows the law of Mariotte and Gay Lussac may be represented by $V=f(pd/T)$, p being the pressure of the gas, T its absolute temperature, and d the distance between the plates from which the discharge occurs. In a more general manner the explosive potential may be considered as a function of the product md, m being the number of molecules contained in unit volume of the gas, for the same gas at different pressures; m is thus proportional to the density of the gas. The present experiments carried out at ordinary temperature on carbon dioxide help to establish the truth of the relationship $V=F(md)$. The experiments have been made at pressures varying between 5 and 45 atmos. and for distances 0·84 mm. to 2·24 mm. From the curves given it appears that it is not possible to represent V as a function of pd by a single curve, whereas, V as a function of md can be grouped around a single curve whatever the distance between the electrodes. The expression $V=F(md)$ therefore applies to compressed gas within much larger limits than the law of Mariotte and Gay Lussac. This furnishes a new proof of the truth of the kinetic conceptions on which the theory of the disruptive discharge is based.

A. E. G.

806. *The so-called Magnetic Rays of Righi; Electrical Oscillations in Geissler Tubes and the Periodic Interruption of Spark Discharges.* **J. E. Ives.** (Phys. Rev. 9. pp. 349–370, May, 1917.)—The object of the experiments described is to explain, in terms of well-known principles, the phenomena which led Righi to assume the existence of magnetic rays. The discharge tube used is similar to, but simpler than, that used by Righi. A side tube contains the anode and kathode; a long horizontal tube opens into it opposite the kathode. The side tube is in series with a high-potential battery, a non-inductive high resistance and a double switch. Under the proper conditions a magnetic field transverse to the side tube causes the discharge therein to become periodic and at the same time a bluish-violet glow extends into the long tube (the so-called magnetic rays), beyond which is a pink glow and farther on again a blue-white glow. From the behaviour of the two last it seems that a current flows away on each side of the region (the virtual anode) between them.

The magnetic rays have been investigated by various observers, who have come to the conclusion that they are kathode rays moving in spirals about the lines of magnetic force, but the investigations do not explain the other columns, the virtual anode, and the periodicity of the discharge.

The author finds that the periodicity of the discharge depends not only on the magnetic field, but also upon the capacity of the long tube. By varying the capacity it is possible to obtain a frequency ranging from one discharge every few seconds to a frequency above the limits of audibility. For each interruption charges appear in the long tube: an initial positive charge and a residual negative charge. When a steady current flows through the side tube, the long tube always acquires a positive charge: when the current is interrupted this positive charge will flow back towards the kathode and a complete electrical oscillation may take place.

It is found that all the Righi effects can be obtained without any magnetic field if a suitable spark-gap is placed in the circuit on the anode side of the tube and a high resistance on the kathode side. With the gap closed the current is continuous, but on opening it a stage is reached when the discharge becomes periodic and the Righi column appears in the long tube. Also if the tube is replaced by a high non-inductive resistance, shunted by a capacity, the current becomes periodic. Thus a current through a circuit of high resistance and small inductance containing a battery and spark-gap can be changed from a steady to an interrupted current by attaching a capacity to one of the terminals of the gap, and it is shown (by a neon tube) that electrical oscillations are set up across the gap. A theory is given for this action.

Hence it seems that the Righi-effects are not dependent on the magnetic field, but are probably produced by the periodic interruption of the current. A study of the volt-ampere characteristics of tube and gap shows that the interruption of discharge across the gap is due to the fact, taken in conjunction with the fact that the Righi tube has an appreciable electrostatic capacity, that the characteristic of the gap is a falling one. The capacity of the tube causes an electrical oscillation, and this, combined with the falling characteristic, produces the interruption.

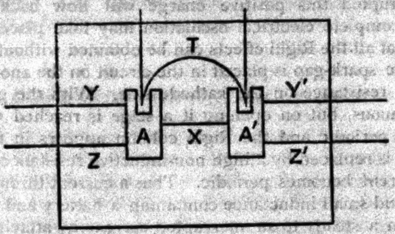
It is also shown that the Righi effects can be produced without either a magnetic field or a spark-gap if the gas pressure in the tube is sufficiently reduced. With a p.d. of 21×10^3 volts and 5×10^6 ohms in series the effects were obtained at a pressure of 0·085 mm. when the current was 0·2 milliamp. Above this pressure the current was continuous; below it, discontinuous and the effects appeared. Probably, at these pressures, the volt-amp. characteristic for the tube becomes a falling one for very small currents, and the discharge then becomes unstable for a certain value of the current given by Kaufmann's criterion.

When the spark-gap is used to give the Righi effects it is probable that the periodic interruption of the current, caused by the capacity of the tube and the instability of the gap, produces a periodic charging and discharging of the long tube: the negative column (blue-white glow) corresponds to the charging and the positive column (pink glow) to the discharging. An actual oscillation takes place in the long tube and is made visible by the light resulting from ionisation of the gas. The virtual anode is the region where the charging and discharging streams are both visible. In Righi's case the magnetic field apparently interrupts the discharge.

The author concludes that the effects observed by Righi are not due to any new kind of ray (the magnetic ray), but to the periodic charging and discharging of the tube. T. H.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

807. *Measurement of the Peltier Coefficient and Thermal Conductivity.* **G. Borelius.** (Ann. d. Physik, 52. 4. pp. 398–414, May 10, 1917.)—The author describes an apparatus suitable for comparing the thermal conductivities of metals and the Peltier coefficients of combinations when the materials employed may be in the form of short rods or wires. One metal, X, is fixed between two similar copper blocks, A, A′. Current may be led through X either by YY′ or by ZZ′. YY′ are copper wires; ZZ′ are wires of constantan. The apparatus is isolated in a constant-temperature enclosure and is symmetrical about the central line. The thermo-element T is connected to a galvanometer: its deflection will depend on the temperature difference between A and A′.



If π, π_1, π_2 denote the Peltier coefficients at the same temperature of the combinations YZ, YX, and ZX respectively, and if w is the heat conducted by X for a temperature gradient of 1 deg. C. per cm., then the author shows theoretically that $\pi_1/\pi = \theta_1/(\theta_2 - \theta_1)$ and $w = a\pi[1/(\theta_2 - \theta_1) - 1/\theta_0]$. Also $\pi = \pi_1 - \pi_2$. θ_1 is the deflection of the galvanometer when the circuit is completed through YXY′, θ_2 that when the same current passes through ZXZ′, and θ_0 the deflection when X is removed and the current passes through YZZ′Y′. a is a calibration constant depending on the thermocouple circuit. If π is known, the Peltier coefficients of various combinations can be determined absolutely. It is not necessary to wait for the final deflection of the galvanometer when determining the Peltier coefficients, as the time functions of the deflections θ_1, θ_2 are the same in each case. A mean value can be determined by observing the deflections at definite intervals of time.

By using two current-sources of suitably chosen strength passing simultaneously by YXY′ and ZXZ′ the Peltier heat could be compensated and the coefficient determined. The author does not consider this latter method so advantageous as the one adopted. It is shown that the heat developed on account of the Joule and Thomson-effects is negligible. Results of experiments made with the apparatus in which X was a tin wire 1·2 mm. in diam. and of various lengths (1·72, 4·81, and 7·17 cm.) are given in tables, and show good agreement with one another. L. L.

ALTERNATING CURRENTS AND MAGNETISM.

808. *A Method of Observation and Measurement of Rapid Periodic Magnetic Phenomena.* **P. Woog** and **J. Sarriau.** (Comptes Rendus, 164. pp. 605–607, April 16, 1917.)—The method employed is to make vibrate a small piece

of metal attached to a Koenig manometric capsule. An examination of the deformations of the flame due to the vibrations transmitted to the capsule enables a study of the magnetic field of the vibrator to be made both as regards magnitude and variation. So as not to introduce perturbation a glass capsule is employed. The metal is a disc of iron, 18 mm. thick, with a hole 6 mm. in diam. in its centre; it is fastened to the membrane on the outside of the capsule. The capsule is traversed by a current of coal-gas at a constant pressure of 18 mm. of water. The electro-vibrator is placed perpendicularly to the membrane and 62 mm. distant from it. The observations of the flame are made by means of a rotating mirror, or the results may be registered photographically. A. E. G.

809. *Magnetic Properties of Iron, Nickel, and Cobalt above the Curie-point, and Keesom's Quantum Theory of Magnetism.* **E. M. Terry.** (Phys. Rev. 9. pp. 394–413, May, 1917.)—Curie's experimental law that the susceptibility of a paramagnetic substance varies inversely as the absolute temperature was accounted for by the theory of Langevin [see Abs. 1449 (1905)]. Weiss, introducing the idea of an internal magnetic field proportional to the intensity of magnetisation, extended the theory to ferromagnetic substances. He arrived at the result, that in the temperature interval above the magnetic transformation point ["Curie" point] the susceptibility varies inversely as the excess temperature above that point. In addition, the constant of proportionality is the same as would have held for the substance, if by suppression of mutual action between the molecules it had remained paramagnetic. Weiss introduced the idea of the "magneton," a natural unit magnet, and showed that the number of magnetons per molecule is related to the Curie constant of the substance. The results of recent investigators in this domain have shown that the Curie law is not general, and the existence of the magneton, at least as based on the theory of Weiss, is open to question.

In the present paper the author describes his measurements of the susceptibility of Fe, Ni, and Co from the Curie point to the melting-point. The method consisted in observing the force on a small specimen placed in a non-uniform magnetic field. A modified form of Curie balance was employed in which the torque was balanced by the electrodynamic action between two coils, one fixed and the other mounted on the moving system. The balance was standardised by the use of several solutions whose susceptibilities were measured by the Quincke absolute method. The iron used in the investigation was Burgess' electrolytic iron and had a purity as regards other metals of 99·98 %. The Ni and Co were supplied by Kahlbaum in the form of powders. All specimens were freed from occluded gases by preliminary melting *in vacuo.* The tests were carried out *in vacuo*, the pump running continuously during measurements and the pressure seldom exceeding more than 0·0005 mm. of Hg. Temperatures were measured by a Pt and Pt-Rh couple which was calibrated in position in the vacuum furnace, the melt specimens [Cd, Sb, Au, and Ni] being introduced at the place occupied subsequently by the magnetic material to be tested. The pole-pieces of the electromagnet were specially designed to give a broad peak to the F–X curve. Tables of results and curves are given in the paper. For β-Fe Curie's law is only approximately obeyed, the curve between reciprocal of susceptibility and temperature showing a marked upward concavity. The value of the susceptibility drops considerably on transformation to γ-Fe and in this region remains almost constant for about 500 deg. At 1407° C. there is an abrupt increase when the transformation to the δ form occurs. Throughout the δ region which extends to the melting-point (1530° C) the susceptibility decreases approximately linearly with the temperature. Electrolytic iron, as deposited, shows slightly greater values of susceptibility in the γ, and smaller values in the δ region than the same iron after being melted *in vacuo*. The transformation from β to γ shows a marked temperature hysteresis effect, but not so that from γ to δ. Ni shows a tendency to obey Curie's law, but for limited regions only. On passing through the melting-point there is no change in the magnetic behaviour. β-Co is similar in its behaviour to β-Fe. Keesom introduced the quantum theory into Weiss's theory of the ferromagnetic state [see Abs. 843, 844 (1914)]. The author's results, however, only agree with this qualitatively. The assumption of a larger zero-point energy in Planck's equation does not bring the theory into line with the experimental data. L. L.

810. *Optic and Magnetic Properties of Colloidal Iron Hydroxide.* **R. Gans and H. Isnardi.** (Ann. d. Physik, 52. 2. pp. 179–194, March 6, 1917.)—Majorana observed in 1902 that colloidal iron solutions are double-refracting in the magnetic field; Schmauss attributed this to the orientation of the particles; changes in the field intensity and in the temperature changed the sign of the refraction. Cotton and Mouton proved that this inversion is not due to any change of the paramagnetism of the colloidal particles (with respect to the water) into diamagnetic iron, and Diesselhorst and Freundlich showed that the colloidal particles are practically spherical, not like rods or discs [see Abs. 1090 (1916)]. The authors place a trough containing the colloid, jacketed for observations at different temperatures, between the pole-pieces (50 mm. by 15 mm.) of an electromagnet, passing the polarised beam longitudinally through the trough. The double refraction Δ, which is measured with the aid of a Babinet compensator, is found to increase with the concentration of the colloid and with increasing field (up to 19,000 gauss), but there is no change from para- into dia-magnetism; the pole-gap was varied between 9 and 26 mm. Experiments as to the temperature changes between 0° and 80° show that the double refraction Δ is positive at low temperature, and becomes negative at higher temperature; the temperature of inversion lies higher for aged than for fresh solutions (*e.g.* 33° against 12°), and rises also slightly with increasing field intensity: after attaining a minimum on the negative side the inversion curve rises again; this minimum lies also at higher temperature in aged solutions (55° against 35°) and is independent of the field intensity, but the value of $(\Delta_t - \Delta_0)/tH^2$ is approximately constant. In the experiments on the magnetism of the colloid the pole-pieces were of the Weiss-Foëx shape, the ends being planes intersecting at 120°, with a minimum pole gap of 9 mm. The solution is contained in a glass tube which is attached at right angles to a glass rod, the other end of which bears a mirror; the glass rod is suspended by two V straps of copper. The observations confirm that the solution is always paramagnetic; the susceptibility of the particles increases with increasing field and with decreasing temperature. The particles may be magnetically isotropic, but they probably deviate sufficiently from the spherical shape to be directed in a homogeneous field, thermal agitation opposing the directive forces. H. B.

811. *Application of the Theory of Magnetism to Anisotropic Liquids.* **F. Grandjean.** (Comptes Rendus, 164. pp. 280–283, Feb. 5, and pp. 431–434, March 12, 1917.)—A mathematical paper not suitable for abstraction. A. F.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

812. *Rapid Radioscopic Localisation of Projectiles.* **J. Fromentin.** (Comptes Rendus, 164. pp. 519–520, March 26, 1917.)—A metallic localiser firmly attached to the tube is used. The circular base of the localiser carries two wire threads, which cut one another at the centre of the circle. The normal ray from the tube should pass through the crossing point. The tube is arranged so that the image of the foreign body and that of the crossing point coincide. This image, B, is marked on the screen, as is also the point on the skin through which the normal ray passes. The screen remains fixed at a constant arbitrary distance from the antikathode, the tube being displaced until the image of the foreign body coincides with that of another point on the circumference of the base of the localiser; a second point, C′, on the screen is thus obtained. The apparatus is so constructed that the ratio (Distance of crossing from antikathode/Radius of base of localiser) can be represented by a whole number. This number multiplied by C′B will then give the distance of the projectile from the screen. This method has the following advantages:—The tube may be at any distance from the screen; the calculation necessary is easy; the localiser gives clear images; all the manipulations are made in the dark; the time of localising is greatly reduced and the whole arrangement is very simple. A. E. G.

813. *Induction-balance Method for Localisation of Projectiles.* **S. Procopiu.** (Rev. Gén. d'Él. 1. pp. 888–889, June 9, 1917. Comptes Rendus, 165. pp. 109–110, July 16, 1917.)—The author describes a method of localisation which is based upon the use of the Hughes induction balance. The chief feature is the use of a galvanometer as indicating instrument, whereby, it is claimed, greatly increased sensibility is attained. The alternating or intermittent current used for the primary of the balance, being unsuitable for use with the galvanometer, is rectified by means of a galena-detector inserted in the secondary circuit. Since an accurate null reading is generally unattainable with the two windings, a potentiometer circuit, which must be of low resistance, is included in the galvanometer circuit in order to get a zero reading.

The author has made use of this method, using the a.c. supply of Bucharest (120 volts, transformed down to 45 volts, and 8 to 6 amps.), and has obtained good results. The galvanometer employed was of sensibility 4×10^{-6} amp. A 15-gm. ferro-nickel machine-gun bullet (Rumanian) produced the following deflections:—

Distance of bullet from core ...	10	8	6	5	4	3 cm.
Deflection of galvanometer......	4	8	25	40	110	200 mm.

L. H. W.

814. *Geometric Properties of X-ray Bundles: Application to Localisation of Foreign Bodies.* **J. Pellissier.** (Comptes Rendus, 164. pp. 516–519, March 26, 1917.)—A very simple method of localisation of foreign bodies deeply embedded in the tissues, is based on the properties of the anharmonic ratio and of the homograph. By the aid of the radioscope the normal incident ray passing through the body is obtained, and two lead marks are arranged on the surface of the body. The remainder is accomplished by using an ordinary X-ray tube. The arrangement of the necessary apparatus is described, and it is shown that the depth of the foreign body below the surface is given by $x = h(H - h)/[m(H - h) + Hn]$, where H is the height of tube above the photographic plate, h the distance between the lead markers, and *m* and *n* are the distances between the images of the markers and that of the foreign body. It is further shown that the theory of the homograph enables a simplification of the above solution to be made by using a single marker only. A. E. G.

815. *New Composition Opaque to X-rays.* **Angebaud.** (Archives d'Él. Médicale, 25. pp. 216–220, May, 1917.)—The essential feature of a radiological installation is a screen for the tube which effectively limits the field of operation of the rays. Attempts to produce such a screen have been made by incorporating with glass or ebonite certain salts opaque to the rays, but unfortunately the results obtained have not been satisfactory, as the quantity of salts used has to be strictly limited, since when beyond a certain proportion is present the composition obtained is no longer homogeneous and, in the case of certain rubbers, disintegrates with time. A composition has now been found in which the amount of salts contained is very great, and it is claimed that this new substance possesses the following properties :—It is very opaque to the rays, 9 mm. being more opaque than 2 mm. of lead ; it is not brittle ; it is opaque to light ; it is very light compared with those in use of the same opacity ; it is regular in thickness and easily workable ; it is a good insulator at both high and low tensions, and it is not expensive. Photographs showing comparative experimental results are given. A. E. G.

816. *Ultra-violet Radiation in Relation to Treatment by Ultra-violet Rays.* **C. A. Schunck.** (Röntgen Soc., J. 13. pp. 25–31 ; Disc., 31–36, April, 1917.) —The object of the work here dealt with was the comparison of some sources of ultra-violet radiation used for therapeutic purposes, showing their constituent radiations, wave-lengths and relative intensities, and to ascertain what radiation is most efficient for such purposes. The sources of radiation examined consisted of metallic electrodes of pure tungsten, molybdenum, and iron ; ¼-in. carbon rods impregnated by boiling in solutions of sodium tungstate, uranium nitrate, ammonium molybdate, and titanous chloride ; and ½-in. cored carbons filled with U_3O_8, Fe_2O_3, wolfram ore, and pure tungsten and molybdenum (99 %) in powder form, together with the Simpson electrodes. The results obtained show that the most intense and richest source of ultra-violet radiations is that of the tungsten metallic electrodes in the arc, giving lines so close together as to form an almost continuous spectrum extending to $\lambda 2180$ (the limit of the instrument used) with but slight loss of intensity. This spectrum and that of the Simpson electrodes extends further with the same current and exposure than any of the other sources examined. Details are given of the behaviour of all the different sources, and about 50 photograms are reproduced. A number of therapeutical tests carried out lead to the conclusion that the radiations of greatest therapeutic value lie between $\lambda 3000$ and $\lambda 1850$. Further experiments tend to show that radiations shorter than $\lambda 2250$ have little therapeutic value, judged by the erythema effect alone. It was also found that carbons cored with tungsten powder were quite as effective as metallic tungsten electrodes if the current was increased from 9 amps. to 15 amps. A. W.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

817. *Palladium-Gold Crucibles as Platinum Substitutes.* (Met. and Chem. Eng. 16. p. 583, May 1, 1917.)—The "Palau" crucible, made of an alloy of Pd and Au (percentages not stated), so far as resistance to loss on heating to 1200° C. is concerned, is superior to Pt containing about 2·4 % of Ir, and somewhat inferior to Pt containing about 0·6 % of Rh. The comparative freedom from iron is an improvement over most platinum ware now in use. "Palau" compares favourably with Pt in resistance to HCl, HNO_3, HF, and H_2SO_4, to $FeCl_3$ and NaOH solutions, and fused sodium carbonate. It is not as suitable for potassium pyrosulphate fusions as platinum. For fusions with sodium carbonate and sodium nitrate it is less attacked than Pt, but both metals were seriously attacked under the conditions of the test made, the fusion mixture containing no oxidisable material. "Palau" does not wet, so that the meniscus is downward, as in the case of mercury. The density of "Palau" is 17·22 at 4° C.; the melting-point is 1870° C. T. S. P.

818. *Glucinum* (*Beryllium*) *and its Alloys.* **G. Oesterheld.** (Zeits. Anorg. Chem. 97. pp. 1–40, Sept. 12, 1916. Engineering, 103. pp. 599–600, June 22, 1917.)—Like Fichter the author prepares his metal by electrolysing the fused fluoride $NaGl_2F_5$ (from the carbonate), compressing the resulting metallic powder into cylinders, and heating these in a vertical vacuum electric furnace until a metal of 99·5 % fuses out; this glucinum melts at 1278° ± 5°. The powder retains sodium fluoride, and the metal is prone to cover itself with a film of oxide and to form carbide; in the presence of CO both these reactions take place. The heat of fusion of the metal, 277 cals. per gm., is the highest known for metals; according to Compton it should be higher still, 341 cals. (high melting-point, low atomic weight 9). The alloys are prepared in small bulks, in tubes or crucibles of unglazed porcelain or magnesia. Glucinum and Al are miscible; the solid solutions contain up to 8 % of Al, the eutectic point is 644°; there are no compounds. Whether Gl alloys with Mg, which (according to Fichter) it does not resemble as much as was formerly believed, could not be studied, as Mg boils below the melting-point of Gl. With copper Gl forms alloys of a complex character and probably two compounds, Cu_2Gl and $CuGl_2$ (reddish-grey in colour), in addition to four series of mixed crystals; quenching tests were also made. The addition of Fe to Gl lowers the magnetic transformation point of the iron to 650°. There is one compound, apparently $FeGl_2$, melting between 1400° and 1450°, and a eutectic point at 1155°. Silver and Gl do not seem to combine, although a transformation point at 748° may be due to a compound; there is a eutectic point at 878° and 16 atoms % of Gl; the ductility of the alloys decreases and the hardness increases, with increasing glucinum percentage. H. B.

819. *Nature of the Elastic and Plastic Conditions of Matter.* **I. I. Ostromisslenski.** (Russian Phys. Chem. Soc., J. 47. pp. 1995–2014, 1915. Chem. Soc., J. II. pp. 178–180, 1916. Abstract.)—The two new constants for colloids, namely, the elasticity point and the fatal temperature [Ibid. 47. pp. 1374–1441) 1915)], permit of the characterisation of two new states of aggregation of matter: (1) the plastic state, in which a substance exists in the interval of temperature between the elasticity and fatal points, and (2) the

elastic state, corresponding with the interval between the elasticity point and the melting-point. The supposition that these states of aggregation are properties of all colloids is confirmed experimentally, and since the colloidal condition is common to all forms of matter, the elastic and plastic states are general forms of aggregation. T. H. P.

820. *New Element.* **W. Bramley, S. C. F. Lister.** (Chem. News, 115. p. 182, April 20, and p. 288, June 15, 1917.)—Bramley gives an account of an element which comes down in the iron group. Lister has little doubt that the element in question is europium, and gives a table of the spectral lines which are most suitable for its detection. T. S. P.

821. *Alloys of Chromium, Copper, and Nickel.* **D. F. McFarland** and **O. E. Harder.** (Univ. of Illinois Eng. Experimental Station, Bull. No. 93. [57 pp.], 1916. Mech. Eng. 39. pp. 405–406, June 1, 1917.)—Gives the results of an extensive research on the preparation and properties of the alloys of chromium, copper, and nickel. It is shown that castings of Cr-Cu alloys containing up to 13 % Cr can be prepared by melting and pouring the metals at about 1600°. Cr-Cu alloys containing more than 6 % Cr show a separation of Cr or of a Cr-rich constituent on slow cooling. The addition of Ni to alloys of Cr and Cu tends to prevent the separation of the Cr or Cr-rich constituent; when the Ni present is more than 8 times the amount of Cu present, the alloys become practically homogeneous.

The results of physical and mechanical tests carried out on the alloys are given and may be summarised as follows:—The specific gravity of the alloys varies from 8·92 in the case of the alloy containing Cu 71, Ni 29, to 7·89 for the alloy containing Cu 11, Cr 47, Ni 42; it is found to decrease as the Cr is increased.

The Brinell hardness number varies from that of pure copper (67) in the case of the alloy containing Cu 42, Ni 58 to a hardness of tool steel (228) for the alloy containing Cu 11, Cr 57, Ni 32.

The modulus of elasticity of the 16 alloys tested varies from less than 15,000,000 to more than 50,000,000 lbs. per sq. in., generally increasing with an increase of Cr.

The ultimate strength of the 18 alloys tested varied from 10,000 to more than 50,000 lbs. per sq. in. The reductions of area and the elongations were small in every case.

More than 800 corrosion tests were carried out, the results of which show that the amount of corrosion is not proportional to the strength of the acid or base. A triangular system of plotting the results shows certain fairly well-defined areas which are highly resistant to corrosion. In general the ternary alloys are less corroded than the binary, though there are some exceptions.

A microscopic study of the alloys was made, and the results agree with Voss's conclusions that Cr and Ni form a series of solid solutions over the range from 100 to 50 % of Ni and that they form a eutectic containing about 42 % Ni. The results on the Cu-Ni series agree with those of Guertler and Tammann in showing a continuous series of solid solutions. All Ni-rich alloys, both binary and ternary, show well-defined polyhedral crystals.

The results indicate that the alloys of Cr-Ni-Cu which show possibilities of becoming of commercial importance are limited to certain fairly well-defined ranges of composition. C. O. B.

822. *Failure of Brass.* II. *Effect of Corrosion on Ductility and Strength of Brass.* **P. D. Merica.** (Bureau of Standards, Techn. Papers, No. 83.

[7 pp.], Washington, 1916.)—Records the results of experimental measurement of the electrolytic potential of brass under stress. For the tests two electrodes of ½-in. brass rods were used after annealing at 400° C. These were placed in the electrolyte, either zinc sulphate or zinc copper sulphate, protected from the air, and the e.m.f. noted from time to time under zero stress; stresses were then applied in units of 10,000 lbs. per sq. in., and the e.m.f. again noted.

An increase in the e.m.f. of alpha brass to solutions containing zinc and copper ions has been indicated by the application of tensile stress, amounting to 0·2 millivolt for 20,000 lbs. per sq. in. (below the elastic limit) to about 1 millivolt at the yield-point of the material, 30,000 lbs. per sq. in.

An explanation is thus given of the effect of corrosion on brass under stress in decreasing the ductility and strength. At the bottom of small furrows in the roughened surface, caused initially by corrosion, the stress is greater than at ridges immediately adjacent; a galvanic couple is formed and the bottom of the furrow only is corroded, forming in time a crack which becomes narrower and sharper as it penetrates inwards, finally so reducing the cross-section that fracture occurs. [See also Abs. 815B (1917).]
C. O. B.

823. *Atmospheric Corrosion of Commercial Sheet Iron.* **E. A. Richardson** and **L. T. Richardson.** (Am. Electrochem. Soc., Trans. 30. pp. 379–389; Disc., 390–400, 1916. Chem. News, 115. pp. 62–65, Feb. 9, 1917. Met. and Chem. Eng. 15. pp. 450–453, Oct. 15, 1916.)—Gives a brief summary of previous work on the corrosion of iron, specially dealing with that relating to the influence of copper and mill scale.

For the experimental work black sheets of No. 26 gauge of the following materials were used: Bessemer steel, open-hearth steel, charcoal iron, two samples of commercially pure iron, copper-bearing iron, copper-bearing steel, copper-bearing Bessemer steel, and copper-bearing open-hearth steel. The analyses of these materials are given, the copper varying from traces to 0·268 %. Part of each specimen was tested in the condition as received, and part after the removal of the mill scale.

Prepared pieces were exposed to atmospheric corrosion, and from the first the character of the rust formed on the different materials was found to differ considerably. Whereas on the Bessemer and open-hearth steel samples the rust was of a yellowish-red colour and became loose rapidly, the rust on the others was dark in colour and much more adherent; this adherent condition reached its maximum in the copper steels, where the rust was very dark and fine-grained.

As a result of the tests it is concluded that copper-bearing steels are decidedly superior to pure iron, steel or charcoal iron. The addition of copper to pure iron increases its resistance to corrosion, but not to the same extent as similar additions to steel increase the resistance to corrosion of this material. Charcoal iron and pure iron are superior to steel as regards resistance to atmospheric corrosion.

Copper is supposed to decrease corrosion, due to some mutual influence of Mn and Cu, and the addition of larger amounts of Mn and Cu to pure iron or steel is suggested, as well as additions of copper-chromium, copper-vanadium, copper-tungsten, and copper-molybdenum.

Mill scale was found to stimulate corrosion in rapidly corroding materials and to retard it in slowly corroding materials.
C. O. B.

824. *Effect of Rust upon the Corrosion of Iron and Steel.* **J. Aston.** (Am. Electrochem. Soc., Trans. 29. pp. 448–464; Disc., 464–468, 1916.)—As a result of observation and study of the characteristics of rust the following conclusions are given :—(1) Rust plays a *rôle* in the electrochemical relations at least equal to that of constituents usually assumed to be highly detrimental. (2) Very probably in all cases, but almost certainly when rust is freshly formed, its influence is not as an electrode, but as a coating which affects the polarity of the underlying iron. (3) Rust plays a dual *rôle*; the underlying iron may be anodic or kathodic to bare iron, depending upon the state of hydration, but fresh wet rust makes this iron electro-positive. (4) Rust is an accelerator of further rusting.

Each of the above conclusions is dealt with in detail, and tables are given showing the relative magnitudes of electrochemical effect with various couples. The readings given are milliamps. of current flow in a cell with electrodes of 3 × 3 in. immersion and ¼-in. separation.

Wet rust is anodic to bare iron and dry rust is kathodic. Effect of strain is indicated by the electro-positive relation of cold-rolled stock to ordinary iron, varying from 0·12 to 1·4 milliamps. The electro-negative relation of black oxide scale with bare iron was from 0·15 to 0·48 milliamps. initial current flow.

For dry rust against bare iron the effects are somewhat conflicting; thorough wetting of the rust tends to lower its kathodic polarity with respect to the iron, usually to the extent of reversal; after varying periods of immersion it behaves like fresh wet rust. There is also a reversal of polarity after wet rust has dried out, probably due to change of degree of hydration, absorption of gases from the air, or the formation of an oxide or other compound of iron in contact with the metal surface which has electro-negative characteristics of the metallic electrode type.

Since rust promotes electrolytic effects equal to or surpassing those of factors generally recognised as of marked importance, its influence in accelerating further rust must be conceded. The reversal of polarity does not nullify its effect; where drying-out occurs there is a tendency for greater distribution of the rusting effect, while non-reversal of wet rust aids in intensifying the corrosion in concentrated zones.

It is conceivable that an electro-positive constituent of steel, ostensibly, therefore, a protector, may promote corrosion, since the anodic solution of this constituent may result in a colloidal product which will create an anodic zone in the underlying iron.

Paint pigments, after weathering has destroyed the excluding effect of a poor vehicle, may accelerate corrosion of the iron.

All rusting proceeds by pitting, because of a series of alternate anodic zones where solution occurs, adjoining similar kathodic surfaces which are immune. Corrosion in the atmosphere is, however, usually more even, with less pronounced pitting than in underwater or pipe service. In ordinary weathering, relative paucity of electrolyte and abundance of oxygen probably concentrate the zone of influence of the electrolytic effect. In addition, wetting of a dried rusted surface converts the rusted areas into anodes and spreads the rust over the entire surface. The more frequent the alternate wetting and drying, the more even is the rust distribution.

Inclusions in the iron may start localised corrosion and pitting, but they are probably only a minor contributing factor. Lodgment of rust, sediment, organic matter, or initial formation of rust by purely physical differences of surface condition appear to be the general causes. Once rust has formed it will automatically tend to keep the surrounding kathodic metal free from rust, and so long as the rust remains wet there will be concentrations of the corrosion in the restricted zone, with the well-known result of pitting.

The distribution of united rust is largely accidental and is specially influenced by the flow of the water which deposits rust or other matter in streaks in the direction of flow. In still water there is a greater probability of even settlement of any matter and less likelihood of disturbance of newly formed rust. There is thus a greater tendency for more numerous and evenly distributed small pits. C. O. B.

825. *Adsorption of Sulphur Dioxide by Charcoal at* −10° *C.* **A. M. Williams.** (Roy. Soc., Edinburgh, Proc. 37. pp. 161–172, 1916–1917.)—Sulphur dioxide was purified by passing through sodium sulphite solution to free it from traces of sulphur trioxide, through bulbs containing concentrated sulphuric acid to dry, and then liquefied in a flask placed in a freezing mixture of alcohol and carbon dioxide snow which served as a reservoir of the SO_2 and, on withdrawing the freezing mixture, allowed of the subsequent evolution of gas by evaporation. The heat evolution on adsorption by blood charcoal was measured by enclosing the charcoal in a glass bulb immersed in a silvered vacuum cylinder containing liquid SO_2. The outside walls of the cylinder were maintained at a constant temperature by surrounding with a freezing mixture. The volume of gas evolved by evaporation of the SO_2, which passed through a side tube and was collected over mercury, allowed of the estimation of the heat of adsorption in the charcoal tube. The leak through radiation of heat inwards was in all cases below 4 cm.^{3} of gas per min., though in some measurements this amounted to 80 % of the total gas collected. The charcoal before use was thoroughly exhausted for several days during heating, and after surrounding with liquid SO_2, gaseous SO_2 was admitted and the adsorption proceeded at constant volume, the pressure being measured by means of a manometer, and the heat of adsorption calculated from the weight of mercury displaced by the SO_2 from the collecting vessel. Corrections were applied for the heat introduced by the gas entering the adsorption chamber at a higher temperature than the chamber, and for departures from the gas law in the relation between PV and T. On plotting the volume adsorbed, measured at N.T.P. against the final pressure when equilibrium was attained, the curve is of the same type as that obtained by Trouton for the adsorption of water-vapour by flannel. An upward bend occurs with a partial pressure of about 12 cm., and an inflection at about 72 cm., while the gradient does not appear to be infinite at atmospheric pressure, when about 500 cm.^{3} (at N.T.P.) were adsorbed by 1 gm. of charcoal. By plotting the heat of adsorption (or λ_v/λ_l, where λ_v is the isothermal heat of adsorption at constant volume, and λ_l, the latent heat of vaporisation of liquid SO_2, which, from vapour-pressure data, is calculated to be 98·2 cals. for 1 gm. of the dioxide at −10°) against the volume (at N.T.P.) adsorbed, the curve passes through a minimum and a maximum, and finally runs parallel to the adsorption axis. This curve indicates that the heat of adsorption is due to at least two effects: loss of potential energy of the gas undergoing adsorption in yielding to the attraction of (1) the adsorbent, and (2) the gas already adsorbed. The first effect will probably be represented by a function which diminishes, and the second effect by one which increases, with increasing adsorption. In addition to these factors there may be a third term representing the change in energy of the adsorbent. J. N. P.

826. *Selective Properties of the Copper Ferrocyanide Membrane.* **F. Tinker.** (Roy. Soc., Proc. 93. pp. 268–276, June 1, 1917.)—In continuation of the author's work on semi-permeable membranes [see Abs. 880 (1916)] the selective properties of copper ferrocyanide have been studied by measuring the change in solution concentration which takes place when the dry colloid is immersed in cane-sugar solutions of various strengths. Details of the preparation of the copper ferrocyanide are given, and it is only by carefully following the instructions given that a satisfactory material can be obtained. It is found that the sugar solutions become stronger, owing to the fact that the water and not the sugar is taken up selectively by the ferrocyanide. The experimental results are in accordance with the hypothesis that a colloidal hydrate, $Cu_2FeC_6N_6 8H_2O$, is first formed, and that this colloidal hydrate takes up still more moisture by adsorption. The amount of "adsorbed" moisture taken up by the colloid decreases as the strength of the solution increases. The fact that colloidal ferrocyanide adsorbs water selectively from cane-sugar solutions without taking up the sugar at the same time supports the author's theory that the property of selective permeability is, in the case of colloidal membranes, a result of preferential adsorption. It is also shown that the side of a membrane in contact with pure water has a greater moisture content than the side in contact with sugar solution. This fact supports the hypothesis that osmosis across the membrane takes place because pure water induces a greater moisture pressure and concentration in the membrane than the solution does. T. S. P.

827. *Solubility Changes caused by the Presence of Salts.* **H. v. Euler.** (Phys. Zeits. 18. p. 113, March 1, 1917. Paper read before the Deutsch. Bunsen Gesell., Dec., 1916.)—The equivalent change in solubility, AS, produced by salts on non-electrolytes is: $AS = l_w - l_s)/n \, . \, l_w$, where l_w and l_s designate the solubility of the non-electrolyte in water and in the salt solution of concentration *n*. The order of the "de-salting" effect is independent of the nature of the "de-salted" (deposited) non-electrolyte. From experiments with salt mixtures containing mercury cyanide, etc., it would appear that the non-dissociated salt does not take part in this change in the solubility, so that the means of the AS values give the changes in solubility for the gm.-ions. In the case of ammonium salt the thus-obtained value for the NH_4-ion is negative, *i.e.* this ion increases (instead of decreasing) the solubility. The author hence resumed his experiments with aniline salts and amines [see Abs. 1119 (1905)] which had given a marked solubility increase. The research is based on two considerations: (1) These aniline salts decrease the surface tension of water which most inorganic salts increase; (2) they are aromatic compounds which, according to E. Thorin, favour the solubility of ethyl ether whilst aliphatic sodium salts impair it. Experiments with organic nitrates, alkali benzoates, picrates, butyrates, acetates, etc., and also alkali chloride and sulphite show that in most cases those salts, which raise the surface tension of water, de-salt (decrease the solubility of) the compound, whilst those which decrease the surface tension favour the solubility, but there are exceptions (sodium butyrate and isovalerate, both decreasing the surface tension). The rule of Thorin seems to hold in general, but sodium phthalate is an exception. The compounds whose solubility AS was studied were aniline, nitrobenzene, and ethyl ether. H. B.

828. *The Potential of the Hydrogen Electrode at Different Pressures.* **N. E. Loomis, C. N. Myers, and S. F. Acree.** (J. Phys. Chem. 21. pp. 334–337, April, 1917. From 18 series of measurements at different pressures, from 700 to 800 mm., the authors find that the equation $E = RT/2F . \log_e H_2/H_2'$ holds very closely. [See Abs. 268 (1916).] A. F.

829. *E.M.F.'s and Electrode Potentials in Pure and Mixed Solvents.* II. **F. S. Mortimer** and **J. N. Pearce.** (J. Phys. Chem. 21. pp. 275–298, April, 1917.)—The electrode potentials of silver in solutions of silver nitrate in various mixed solvents have been measured at 0° and 25°. The mixed solvents used were: water-pyridine, ethyl alcohol-pyridine, and methyl alcohol-pyridine. In the case of each mixed solvent four series of measurements were made, the concentrations of the one component being respectively 0, 25, 50, 75, and 100 %. The concentration of the silver nitrate varied from 0·005 to 1·0 normal.

The electrode potentials of silver are much higher for solutions in water and the two alcohols than for equivalent concentrations in pyridine; for example, 1·0097 volts in water against 0·5470 volt in pyridine for N/10 solutions. Also, for any given concentration of silver nitrate the electrode potential increases with the decrease in the proportion of pyridine in the solvent mixture. The electrode, potential-solvent curves show a striking resemblance to the dielectric constant-solvent curves for the same mixtures. For all solvents, simple and mixed, the electrode potentials increase with increasing concentration of the solute. The e.m.f.'s calculated for the concentration cells in the pure solvents—water, methyl alcohol, and ethyl alcohol—agree closely with those determined by experiment, that is, the Nernst equation holds for these solvents. For solutions in pure pyridine, however, there is not even an approximate agreement; this want of agreement is ascribed to the electrical conductivity of these solutions being in no sense a measure of the degree of dissociation. Probably complex molecules are formed in solution, which then dissociate. From the measurements at 0° and 25° the temperature coefficients of the e.m.f.'s have been calculated. All are positive except those in the more dilute aqueous solutions. At concentrations slightly greater than N/10 the temperature coefficients in the aqueous solutions become positive. In all solutions containing pyridine the coefficients are extraordinarily high. A table is also given of the calculated heats of ionisation of silver in the various solvents. The solution pressure of silver in contact with pyridine solutions of silver ions is found to be much higher than when in contact with aqueous or alcoholic solutions ($1·77 \times 10^{-10}$ for pyridine, $2·46 \times 10^{-17}$ for water, $2·02 \times 10^{-16}$ for ethyl alcohol, $8·55 \times 10^{-19}$ for methyl alcohol). T. S. P.

830. *Electrolytic Analysis with small Platinum Electrodes.* **F. A. Gooch** and **M. Kobayashi.** (Am. J. Sci. 43. pp. 391–396, May, 1917.)—In a former paper [Abs. 1786 (1912)] an apparatus was described by means of which accurate electrolytic analyses could be carried out on small volumes (about 15 cm.^{3}) of electrolyte. Objection has been raised that the use of such small volumes is impracticable. The authors now show that a similar apparatus with small Pt electrodes, can be used with volumes of electrolyte which are comparable with those ordinarily employed in electrolytic analyses. Only slight modifications are necessary, and accurate results have been obtained in the estimation of copper, nickel, and lead. T. S. P.

831. *New Method for the Passivification of Iron.* **A. Smits** and **C. A. L. de Bruyn.** (K. Akad. Amsterdam, Proc. 19. 6. pp. 880–884, 1917.)—The authors have now succeeded in showing that a thin iron wire when properly cemented into, or fused into, glass becomes passive when immersed in a solution of ferric nitrate. The temperature at which passivity occurs is the higher, the greater the concentration of the ferric nitrate solution; the concentrations of the solutions varied from 0·06 to 0·14 gm.-mol. per litre, the temperature of passivification then rising from 8°–9° to 31°–34°. The effect is not due to nitric acid formed by hydrolysis of the ferric nitrate. The results are in accordance with the theory previously put forward by the authors [Abs. 411 (1916)]. T. S. P.

832. *Some Particular Cases of Current-potential Lines.* I and II. **A. H. W. Aten.** (K. Akad. Amsterdam, Proc. 19. 4. pp. 658–670, and pp. 768–778, 1917.)—The author gives a theoretical discussion of the form of the curve connecting the electrode potential with the current density. Assuming that the ion concentration at the kathode in the solution outside the diffusion layer is C and the concentration at the electrode is c, the thickness of the diffusion layer being δ, then the quantity of ions passing per sec. through 1 cm.² of cross-section is given by $D/86400 . (C - c)/\delta$, in which D is the coefficient of diffusion per day. The charge carried by these ions is equal to the current density d, which is therefore given by $d = 1{\cdot}117D/(C - c)/\delta$. By substitution in the equation for the electrode potential, this may be written in the form $E = \epsilon + 0{\cdot}058/n . \log(C - d\delta/1{\cdot}117D)$. For the limiting value $c = 0$, the current density has a max. value given by $d_{\text{max.}} = 1{\cdot}117DC/\delta$, according to which the limiting kathodic current is proportional to the ion concentration of the solution and to the diffusion coefficient, and inversely proportional to the thickness of the diffusion layer. Similar considerations are applied to anodic reactions. The theoretical equations are applied in the discussion of experimental results and in the consideration of the influence of complex or hydrated ions. The case of the discharge of halogen ions at a silver anode is examined in detail.

In the second paper the author deals with the electrolytic estimation of the halogens, the anodic formation of metal compounds in solution, and the electrolysis of solutions of complex salts. T. S. P.

833. *Inclusions in Silver Voltameter Deposits.* **W. M. Bovard and G. A. Hulett.** (Am. Chem. Soc., J. 39. pp. 1077–1108, June, 1917.)—The work was performed (1) to compare the anode loss and kathode gain and to determine the inclusion in the latter, and (2) to ascertain the value of the inclusions in electrolytic silver as deposited in a standard platinum-cup voltameter. The form of voltameter used was a modification of the Smith form. The results of the experiments to compare the anode loss with the kathode gain are not so conclusive as desired, but, correcting for inclusions, the agreement is within 7 parts in 100,000. The kathode deposit is actually greater than the anode loss, but the inclusions were considerable. In the method used any error in the large amount of manipulation would tend to make the divergence greater, so that agreement within 7 parts in 100,000 represents a maximum. The value of the inclusions in deposits on a Bureau of Standards platinum-cup voltameter has been found to be 6·7 parts in 100,000, giving 1·11798 as the value of the electrochemical equivalent of silver and 96,496 as the value of the faraday. F. E. S.

834. *Electro-deposition of Nickel.* **L. D. Hammond.** (Am. Electrochem. Soc., Trans. 30. pp. 103–131; Disc., 131–134, 1916.) [See Abs. 552B (1915).]—Insolubility of the anode through assuming the passive form is a difficulty frequently encountered in nickel-plating and leads to a decrease in the nickel concentration and an increase in the acid content of the bath, while, conversely, if the anode dissolves more rapidly than the rate of deposition at the kathode, the Ni concentration of the electrolyte will increase and the bath will become alkaline. Measurements were made of the solubility of cast, electrolytic, and annealed electrolytic Ni anodes in electrolytes of nickel sulphate alone and in presence of boric acid, together with various amounts of nickel chloride. The anodic polarisation was determined comparatively by measuring the total voltage between anode and kathode during the electrolysis. The solubility of the anode is most advantageously ensured in electro-plating by the use of pure Ni anodes and the presence of nickel chloride, which is preferable to other chlorides as its addition does not decrease the concentration of Ni in the electrolyte. In electrolytes of nickel sulphate alone, solution of the anode only takes place readily when the nickel is alloyed with a considerable amount of iron or other impurity. The presence of boric acid to the amount of 8 % in an electrolyte of nickel sulphate accelerated the solution of anodes of cast and annealed Ni, though with anodes of electroytic Ni, the metal became more passive at higher current densities. In the deposition of Ni on zinc, the deposits are rendered non-adherent through the marked tendency of the zinc to pass into solution, replacing the Ni. It was found, however, that by employing a higher initial current density, adherent deposits can be obtained on zinc from solutions used for more electro-negative metals. Nickel was also deposited directly on zinc from an approximately half-normal hydrochloric acid solution to which 120 gm. of nickel sulphate crystals per litre were added, but the most favourable electrolyte for this purpose consisted of a nickel salt in presence of sodium citrate, which was found to retard the solution of zinc in presence of the nickel salt. Sodium potassium tartrate and sodium malate have a similar action, but they do not permit the use of as high a current density as the citrate bath. The most satisfactory results were obtained with 240 gm. nickel sulphate crystals, 15 gm. nickel chloride crystals, and 80 gm. boric acid in 1 litre of water. The current density can be varied between 0·5 and 7 amps./dm.^{2}, and pure electrolytic Ni anodes should be used. For deposition on more electro-negative metals, it is recommended to employ the above electrolyte in absence of sodium citrate, when a current density between 0·5 and 10 amps./dm.^{2} may be used, and by raising the temperature to 75° C. this may be increased to 88 amps./dm.^{2}. It was found that the presence of acid is necessary to secure a good deposit and that the part played by boric acid in giving improved deposits consists in maintaining in the electrolyte a constant but small concentration of hydrogen ions. J. N. P.

835. *Electrolysis of Vanadium Salts.* **S. Fischer.** (Am. Electrochem. Soc., Trans. 80. pp. 175–221; Disc., 221–228, 1916.)—A large number of experiments were made with different electrolytes, including the vanadium salts of various inorganic and organic acids, alkali vanadates, alkaline sulphides, double salts of vanadium with ammonia, aluminium, and magnesium, and vanadium fluosilicate and fluoborate. The influence of changes in temperature, current density, kathode material, concentration, the effect of addition agents, and the use of a porous partition to keep katholyte and anolyte separated were investigated. A method claimed by Cowper-Coles to give thin, lustrous deposits of metallic vanadium was also carefully examined. It was found that in accordance with the high heat of formation of its compounds, and because of the great tendency of the element to form vanadates, vanadium cannot be separated electrolytically from an aqueous electrolyte. The reduction at the kathode was found to be limited in most cases to the vanadyl state (V_2O_4) which is blue, but at a temperature of 90° C.

or over, the reduction proceeded to the V_2O_2 state, which is lavender-coloured. Lead electrodes alone give a reduction to the sesquioxide or green state, V_2O_3, at temperatures below 90°; above this temperature, the electrolyte is reduced to V_2O_2. Carbon electrodes reduce the electrolyte to the sesquioxide V_2O_3, and Pt kathodes, at temperatures below 90°, to the vanadyl state, V_2O_4, while above 90°, the lavender state, (V_2O_2) is reached only when porous cells are used. The black deposit obtained on Pt kathodes, which has previously been attributed to vanadium, was found to consist of platinum hydride, and the amount formed was found to increase with the current density, and with the duration of the electrolysis. During the electrolysis of sodium vanadate in neutral or alkaline solutions, when using porous cup partitions, hydrated vanadic oxide (V_2O_5, xH_2O) and oxygen are formed at the anode, and hydrogen is liberated at the kathode with an increase in the alkalinity of the katholyte. The separation of the vanadic oxide is preceded by an oxidation whereby the electrolyte, originally colourless, changes to yellow and finally to dark orange, when the vanadic oxide begins to deposit as a brick-red layer on the anode. The current efficiency obtained in the separation of vanadic oxide amounted in some cases to 96 %, and varied with the nature of the electrolyte and the current density. A neutral electrolyte, a high-current density, and a temperature from 88° to 98° C. gave the highest efficiency. An increased yield was obtained by the addition of hydrogen peroxide, while hypochlorites and permanganates were found to be deleterious. In association with oxides of Fe, Cu, Mn, Pb, Si, Ca, Al, Zn, As and U as in ores, vanadic oxide can be separated by leaching the mixture with sodium hydroxide followed by anodic deposition of the vanadic oxide from the dissolved vanadate. Other metals which dissolve in the solution cause no contamination of the deposited vanadic oxide, though in the cases of Ca, Mg, Mn, Pb, and U, the extraction of the vanadium was hindered through the formation of insoluble vanadates, and in some cases the anodic efficiency in the separation of vanadic oxide was affected. At temperatures from about 60° to 92° C., and with a nearly neutral anolyte, firmly adherent anode deposits were obtained. Higher temperatures and very high current densities have a tendency to cause the formation of colloidal and non-adherent deposits. J. N. P.

836. *Electrolytic Method of obtaining Solid Iodine from Solution.* **L. Pisarshevski** and **S. Tjelni.** (Russian Phys. Chem. Soc., J. 47. pp. 2060–2068, 1915.)—The authors describe preliminary attempts to devise a method of separating iodine electrically from solutions containing iodides, bromides, and chlorides. Lead electrodes, or a lead anode and a carbon kathode, give good results; the lead anode becomes coated with a thin layer of lead iodide, which prevents further combination with the iodine, the latter being deposited in a crystalline crust easy to remove. T. H. P.

837. *Deposition of Copper in Electrotyping Baths.* **W. Blum, H. D. Holler** and **H. S. Rawdon.** (Am. Electrochem. Soc., Trans. 30. pp. 159–171; Disc., 172–174, 1916.)—From a study of the tensile strength, ductility and microstructure of copper deposited from copper sulphate-sulphuric acid solutions, upon graphited wax moulds, the effects of the various conditions of deposition upon the properties of the copper have been determined and are described in detail. As a result of the authors' observations, detailed instructions are given of the conditions for deposition, including temperature, current density and stirring, and also of the composition of the solution. T. S. P.